Deutsche Bank Research

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Current Issues
Global growth centres

Global growth centres 2020
Formel-G for 34 economies

Substantiated, **long-term growth forecasts** are back in the limelight following the New Economy disappointments and some emerging market crises.

With this introductory publication, Deutsche Bank Research launches its new megatopic **"Global growth centres"**. With the help of *Formel-G* (**Fo**resight **M**odel for **E**valuating **L**ong-term **G**rowth), we identify the sources of long-term economic growth, generate substantiated forecasts until 2020 for 34 economies and provide recommendations for investors and economic policy.

Formel-G is an innovative framework, which combines modern growth theory, state-of-the-art econometric techniques and systematic trend analysis. We identified **four major drivers** of GDP growth to be included in *Formel-G*: **population growth, the investment ratio, human capital and trade openness**.

India, Malaysia and China will post the highest GDP growth rates over 2006-20 according to *Formel-G*. Strong population growth, a rapid improvement in human capital and increasing trade with other countries allow average real GDP growth of more than 5% per year in these three countries.

Ireland, the US and Spain are the OECD economies expected to grow most quickly. Solid population growth helps in Ireland and the USA, while per capita GDP growth will be especially strong in Spain.

OECD countries with low population growth like Switzerland and Japan end up at the bottom of the growth league.

The top 5 growth centres until 2020 (GDP growth 2006-2020)
… in the emerging markets   **… and in the OECD countries**

	% p.a.
1. India	5.5
2. Malaysia	5.4
3. China	5.2
4. Thailand	4.5
5. Turkey	4.1

	% p.a.
1. Ireland	3.8
2. USA	3.1
3. Spain	2.8
4. Canada	2.4
5. France	2.3

Source: Deutsche Bank Research

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ISO codes of the countries analysed:

AR	Argentina	JP	Japan
AU	Australia	KR	Korea (South)
AT	Austria	MY	Malaysia
BE	Belgium	MX	Mexico
BR	Brazil	NL	Netherlands
CA	Canada	NZ	New Zealand
CL	Chile	NO	Norway
CN	China	PT	Portugal
DK	Denmark	RU	Russia
FI	Finland	ZA	South Africa
FR	France	ES	Spain
DE	Germany	SE	Sweden
GR	Greece	CH	Switzerland
IN	India	TH	Thailand
ID	Indonesia	TR	Turkey
IE	Ireland	GB	Great Britain
IT	Italy	US	USA

Following the short-term hype during the heyday of the New Economy and some emerging market crises over the past 10 years, corporate strategists, investors, economists and politicians are increasingly interested in substantiated long-term analyses for individual companies and for national economies.

Looking further ahead

Investment projects of companies usually have a time horizon of at least ten years – with often longer horizons in the public sector. **Long-term planning** is necessary and the following issues have to be addressed: in which countries is investment including foreign direct investment particularly promising? Will per capita income rise strongly there? Which investment locations offer particular potential for the reallocation of (vertical) value chains?

Long time horizon of many investment projects

Long-term **growth forecasts** provide important – albeit not the only – input for investors in their decision-making. Furthermore, those responsible for (economic) **policy** are interested in long-term growth analyses as they can deduct concrete advice on how to act. For example: what measures can policymakers in Brazil take to achieve growth rates matching those of China? But also: which countries with increasing economic power in 2020 may also aim at a stronger say in geopolitical matters?

Long-term growth forecasts are an important input for investment strategies, political decisions …

Substantiated long-term forecasts are also of major importance for **business cycle analysis**: the growth rate of potential GDP is the starting point for all business cycle forecasts. A well-based assessment of potential GDP growth helps to answer the question whether strong economic growth in a country may lead to overheating and a subsequent slowdown.

… and for business cycle analysis

Long-term growth forecasts are complicated by the fact that the top performers of **the last 10 years** may not necessarily be the top performers of the next 10 years. Who would have imagined in 1991 that a decade of stagnation would beset Japan? Who would have forecast in the same year that an impressive rebound of the US economy was to follow? Simply extrapolating the past can not provide reliable forecasts. In addition, there is no automatism towards higher income. Low per capita income levels today are by no means a guarantee for above-average growth in the future. If they were, why are there still differences in incomes today? Strong growth requires hard work via complicated processes. Country-specific starting conditions explain why there is no single "ideal" path towards economic success.

No automatism to higher income

To provide reliable answers to these questions and to help companies, investors and politicians in their decision-making, Deutsche Bank Research identifies **global growth centres** for the period up to 2020 in the framework of a new **megatopic**. This introductory study can only summarise the main results and explain the analytical framework of *Formel-G*. Further special notes will focus in more depth on the most important drivers of growth, on our trend clusters and on selected countries.

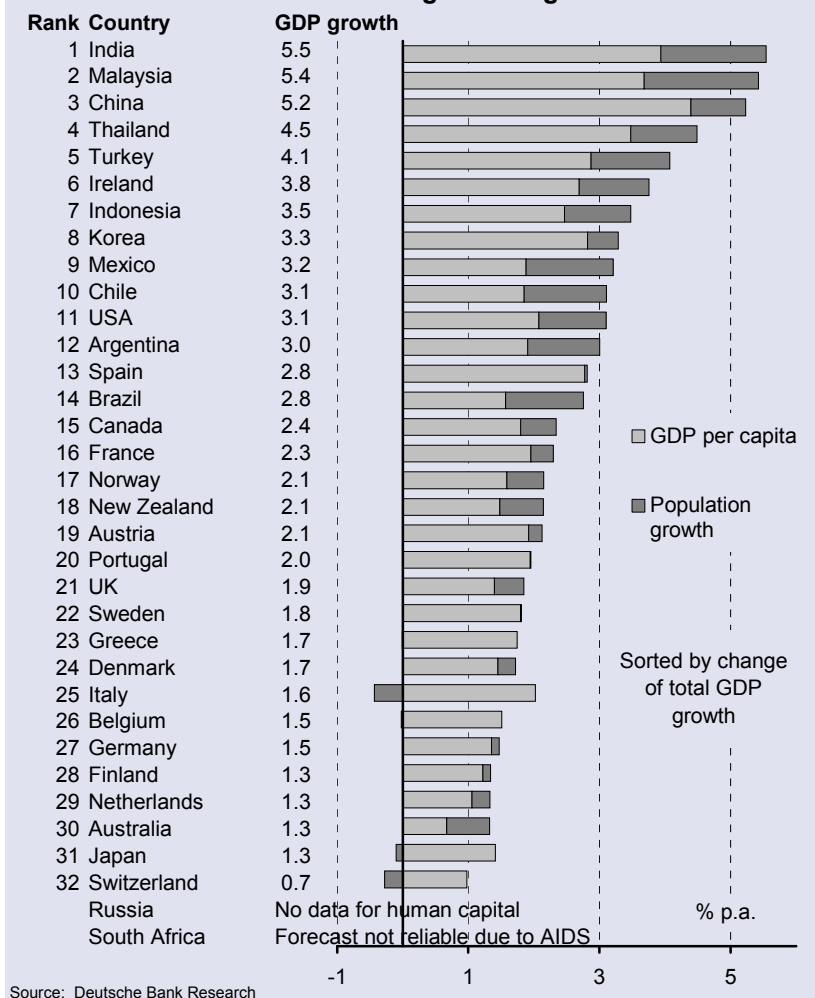**Megatopic "Global growth centres" provides answers**

A. Main results and analytical framework

1. Growth centres 2020: India, Malaysia, China, as well as Ireland, the US and Spain

With the help of *Formel-G,* our **Fo**resight **M**odel for **E**valuating **L**ong-term **G**rowth, we carry out an in-depth test for 34 economies, which is theoretically and empirically substantiated and based on innovative trend analysis (see details from page 8). We are looking for countries posting high growth rates of gross domestic product (GDP, income) overall and on a per capita basis. In addition, a high level of GDP per capita and a history of low growth volatility makes a country even more attractive as a location for exports and investment. According to *Formel-G*, India, Malaysia and China will post the highest GDP growth rates overall during 2006-20, while Ireland, the US and Spain also offer high income levels and low volatility in the past.[1]

34 economies put to the *Formel-G* test

Asian economies ahead in the growth league table

The results of *Formel-G* : Ranking of GDP growth 2006-20

Rank	Country	GDP growth
1	India	5.5
2	Malaysia	5.4
3	China	5.2
4	Thailand	4.5
5	Turkey	4.1
6	Ireland	3.8
7	Indonesia	3.5
8	Korea	3.3
9	Mexico	3.2
10	Chile	3.1
11	USA	3.1
12	Argentina	3.0
13	Spain	2.8
14	Brazil	2.8
15	Canada	2.4
16	France	2.3
17	Norway	2.1
18	New Zealand	2.1
19	Austria	2.1
20	Portugal	2.0
21	UK	1.9
22	Sweden	1.8
23	Greece	1.7
24	Denmark	1.7
25	Italy	1.6
26	Belgium	1.5
27	Germany	1.5
28	Finland	1.3
29	Netherlands	1.3
30	Australia	1.3
31	Japan	1.3
32	Switzerland	0.7
	Russia	No data for human capital
	South Africa	Forecast not reliable due to AIDS

☐ GDP per capita

▪ Population growth

Sorted by change of total GDP growth

% p.a.

-1   1   3   5

Source: Deutsche Bank Research

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[1]   The growth rates presented here are fundamental model projections, which are not necessarily the same as the medium-term forecasts from DB's country experts. Short-term forecasts may of course differ significantly.
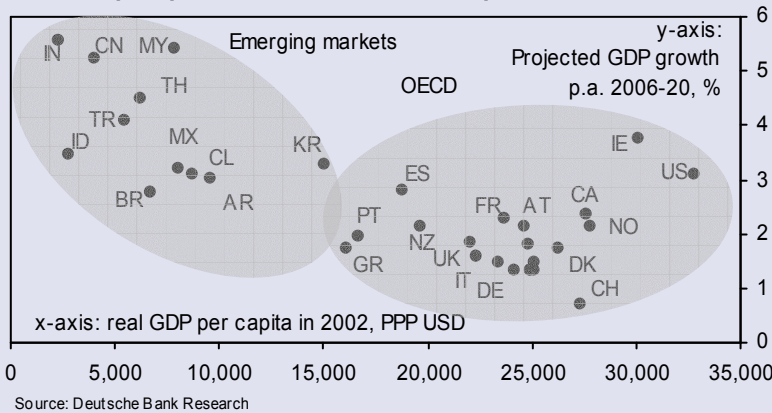
Growth stars among the emerging markets[2]

The star in our global growth ranking is **India**, with an expected annual average rate of GDP growth of 5.5% over the years 2006 to 2020. This model forecast is roughly in line with the current consensus expectations. With a growth rate of 5.5%, real GDP doubles every 13 years. As a result, India will – in purchasing power parity (PPP) terms – take the place of Japan as the world's third-largest economy behind the US and China by the end of this decade. Strong population growth of 1.6% per annum over 2006-20 contributes significantly to overall GDP growth. But per capita GDP is also set to rise significantly, by 3.9%, as human capital will improve rapidly and India will probably continue to open strongly to the rest of the world. With that growth rate, per capita GDP growth doubles every 18 years. However, per capita income in India will still be the second lowest in our group of countries by 2020. Compared to Germany, India's per capita income will rise from 10% today to 16% then.

Malaysia's economy of 25 million inhabitants is set to continue the success of the last two decades. According to *Formel-G*, Malaysia's average annual GDP growth is projected to be 5.4% over 2006-20 – almost as high as in much poorer India. At 3.6%, the rise in per capita GDP would match the growth rate of 1976 to 2000. By 2020 Malaysia's economy will probably be larger than Belgium's or Sweden's (in purchasing power parities). In a few years' time, its per capita income level in PPPs will be higher than Chile's or Mexico's.

In our overall growth ranking, **China** comes in third place with projected annual GDP growth of 5.2% over the years 2006 to 2020. At that rate, China will not become the largest economy of the world by 2020. Growth will be even stronger at the beginning of the forecast period rates of initially almost 7% – albeit below the medium-term consensus forecast of 8% and the average rate of 10% of the past two decades. Trees won't grow into the sky in China – and our model enables us to explain why. The growth differential between China and India stems only from the much slower population growth in China (0.8% p.a.), where the effects of two decades of one-child-policy become evident. Projected average income of the Chinese will rise by 4.4% annually, topping the rate of increase in India. By 2020 China's per capita income in purchasing power parities is set to surpass that of Brazil and almost match Turkey's level (see chart on the right).

Real GDP per capita in 2020

1995 PPP, USD 1,000

Source: Deutsche Bank Research
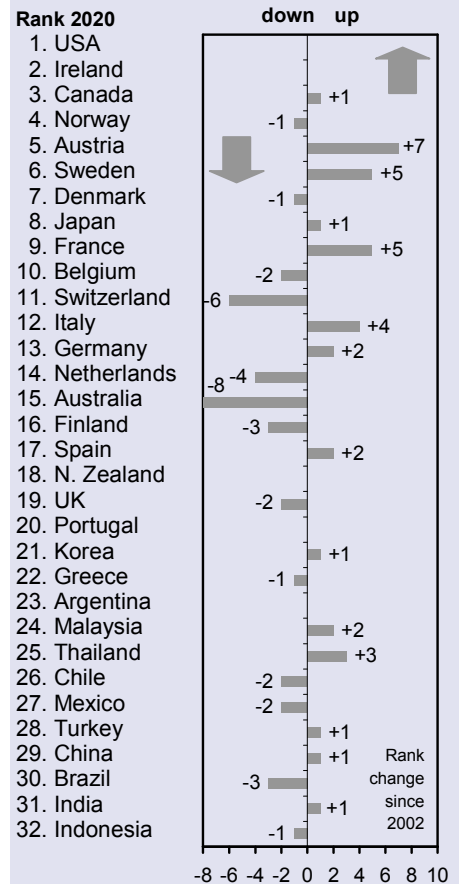
Growth prospects of the rich and the poor countries
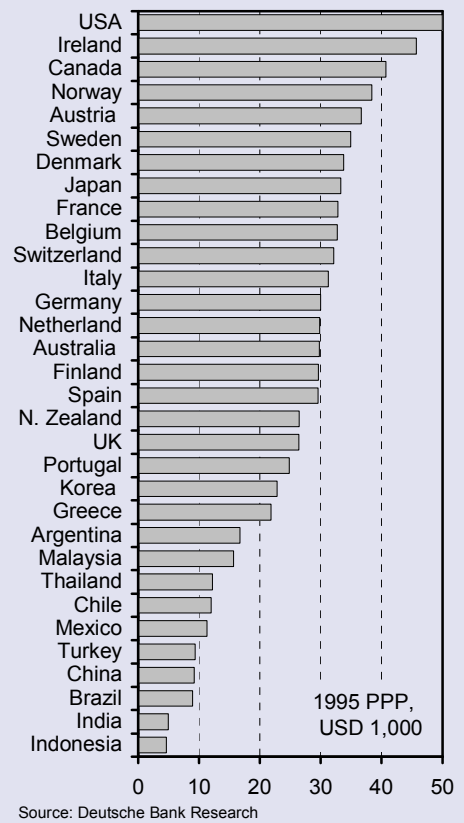
Source: Deutsche Bank Research

Rank change of GDP per capita

Source: Deutsche Bank Research

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[2]   This is only a first overview. Details and reasons for the forecasts can be found in later sections of this publication from page 26.

Latin American countries rank at the **bottom** end of the growth league among the emerging markets. Mexico's proximity to the US and open trade with the US market, enables it to rank just ahead of Argentina and Brazil. In all three countries the drivers of growth are rather weak even though per capita growth rates are set to improve compared to the past. Lack of data prevents us from fully including **Russia** in our framework. However, a noticeably shrinking population and high political uncertainty do not bode well for overall GDP growth going forward. DBR's country experts put Russia's growth potential in the coming years at roughly 4% – slower thereafter. Growth will be partly driven by the expected increase in energy prices, which should benefit Russia as a major exporter of oil and gas.

Significant uncertainties in Russia and Brazil

Growth ranking of OECD economies

Growth rates are not everything. Current per capita **income levels** are also of major importance for the attractiveness of a country as a location especially for exports of up-market products. Furthermore, the closest trade and FDI links today are found among the rich economies. We have therefore produced a separate model ranking growth in OECD countries.[3]

Formel-G projects 3.8% average annual GDP growth in **Ireland** over 2006-20, so it is set to remain the top performer among the OECD countries. The forecast of 1.1% population growth per annum is the highest among the OECD economies. GDP per capita will rise by almost 3% per year. However, a large share of the income generated in Ireland goes to foreigners, so the income of the average Irish is lower than the comparison of GDP levels would suggest. With a population of just 4.7 million in 2020, Ireland will have the second-lowest population in our group and is thus not too significant as a sales market.

The **USA** show that even economies with high income levels can achieve high growth rates of per capita GDP. With GDP growth expected to reach 3% per year, the US ranks second among the rich countries, mainly because it remains at the forefront of technological progress. Thanks to population growth of 1% and per capita GDP growth of 2%, the US economy will continue to post the highest level of GDP overall and per capita in 2020.

Spain's fundamentals, such as the expected rises in human capital and trade openness (bridge between Europe and Latin America and North Africa), also point to solid growth ahead. The successes of the past 20 years are fundamentally justified: with annual per capita GDP growth expected to run at 2.8%, Spain surpasses all other European countries. If immigration continues at the same pace as in the last few years, overall growth could be even higher: the UN population forecasts included in our model have underestimated actual population growth by a full percentage point during the past years since immigration from North Africa and Latin America has overcompensated the low number of births.

Besides Spain, France and Austria will post the strongest economic expansion in **Europe** according to our growth ranking. This is attributable to solid population growth and strong fundamentals. In Italy a sharp rise in human capital contributes to strong per capita GDP growth. With a growth rate of 1.5%, Germany ranks at the lower end of the league table, while Switzerland marks the bottom at 0.7%.

OECD economies: league table GDP growth 2006-20
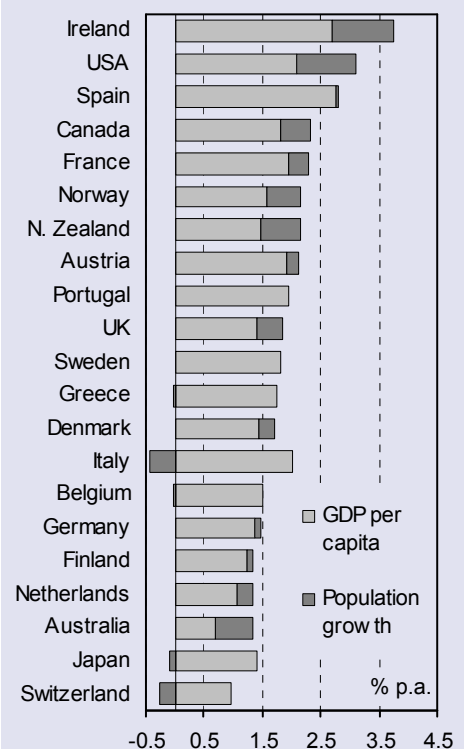
Source: Deutsche Bank Research

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[3] Pre-1994 members. Turkey included in our emerging markets group.

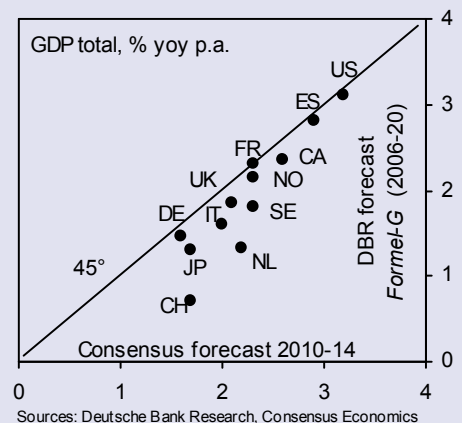## 2. Market too optimistic overall

Some of the results of *Formel-G* are at odds with consensus forecasts and growth competitiveness indicators. Our model is somewhat more sceptical for the rich economies than the **consensus forecasts** published by Consensus Economics for 2010-14.[4] For Switzerland and the Netherlands, the gap is one percentage point; for Japan, Sweden and Italy half a percentage point (see chart). Compared with the long-run forecasts of the economic research institute Global Insight our approach is also more sceptical overall. The gap in forecasts for Chile, Brazil and China is two percentage points, for Indonesia, Turkey, Finland and Switzerland it is one percentage point.

The gaps between the growth forecasts of our model and the World Economic Forum's (WEF) **Growth Competitiveness Index**, which claims to "analyze the potential for the world's economies to attain sustained economic growth over the medium term", are quite pronounced (see chart). In our view, the WEF's index in fact explains differences in current income levels – the correlation coefficient is 0.66. The WEF attributes a higher growth potential to Finland and Switzerland than *Formel-G*. On the other hand, the WEF is more sceptical about the outlook for our top performers in 2020: according to *Formel-G*, the WEF's growth competitiveness index understates the per capita income growth prospects of India and China but also of Malaysia and Thailand.[5]
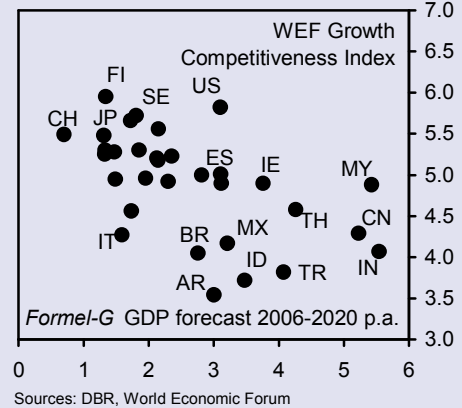
Another positive for our growth centres is the stability of growth in the past, even if **low historic volatility** (calculated as standard deviations of annual growth rates) need not indicate stability in the future. Nevertheless, in the last few decades, economic crises often occurred in the same countries (see chart). However, a strong decline in volatility is likely for example in Turkey (EU orientation) and Brazil.

The countries in our group accounted for 85% of world GDP in the year 2003. GDP per capita growth in these countries is likely to weaken by almost 0.5 of a percentage point in the next 15 years **compared with the period of 1985 to 2000**, falling to an un-weighted average of 2.0%. The growth dip will be particularly pronounced in China, Korea and Chile – although China will remain one of the growth stars according to *Formel-G*. In Europe per capita GDP growth will weaken most perceptibly in Ireland, the Netherlands and Portugal over the same period. But there are also countries which will probably see higher growth rates. This is especially the case in South Africa, where per capita GDP actually shrank over the last decades. Sweden, Brazil and Greece are also likely to show a stronger growth performance than in the 1986 to 2000 period.
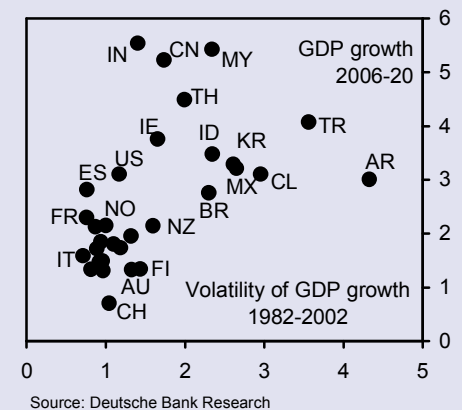

Formel-G vs Consensus Forecast

Sources: Deutsche Bank Research, Consensus Economics

Formel-G forecast vs WEF

Sources: DBR, World Economic Forum

Tradeoff: risk & return

Source: Deutsche Bank Research

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[4]   Consensus Economics, April 2004.
[5]   However, among the emerging markets our growth centres are also assessed relatively positively according to the WEF's Growth Competitiveness Index.

3. *Formel-G* for "Global growth centres 2020"

The results presented here are based on *Formel-G*, our new analytical framework for long-term growth forecasts. This framework combines state-of-the-art econometric techniques with innovative trend analysis to generate annual GDP forecasts until 2020. *Formel-G* has been developed as a crucial element of DBR's new megatopic **"Global growth centres"** and builds on the findings of our megatopics "Demography" and "More growth for Germany". However, more trends and more countries are taken into account, which makes the model significantly more complex.

Our analysis focuses on real GDP with its overall and per capita growth rates until 2020. Of course, GDP is not an ideal yardstick for the wellbeing of the citizens in the various countries, because part of the income generated domestically does not benefit people there but goes to foreign capital owners. In Ireland for example, gross national income was more than 17% below GDP in 2003. Furthermore, leisure, social stability, a clean environment and a high life expectancy contribute to an individual's wellbeing – but they are not included in GDP.[6] Nevertheless, for companies, banks and investors **GDP** will remain the **relevant yardstick for market activities**.

To ensure the **comparability of GDP levels across countries** we have converted them with purchasing power parity exchange rates into 1995 US dollars. Differences in price levels are thus stripped out but GDP growth rates are not affected.[7] The focus of the analysis is thus on GDP growth overall (market size) and GDP growth per capita (prosperity). In the econometric estimate we initially use GDP per capita of the 15-64 age group as the best yardstick of productivity available for all countries; the other variables are calculated with the help of population figures.
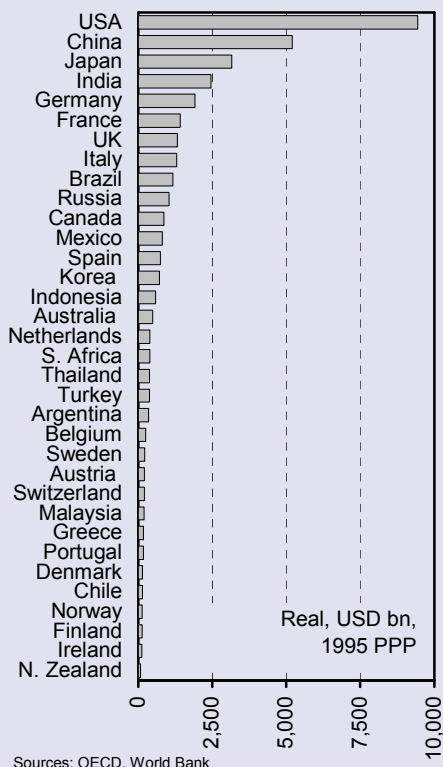
34 countries put to the *Formel-G* test

The size of a country and the **availability of data** were important criteria for the selection of the 34 countries in our model. For example, there are no sufficient time series for the transition countries of Central and Eastern Europe, so we were unable to take them on board. **Size and income levels** of the 34 countries diverge strongly: the spectrum ranges from China and India with a population of currently 1.3 bn and 1.1 bn to small countries such as New Zealand and Ireland with a population of 4 million each – even smaller countries were not taken into account. GDP per capita and year ranged from USD 2,340 in India in 2002 to 14 times that level in the US in terms of 1995 purchasing power parities. For the emerging markets, the heterogeneity and frequent crises in the past evidently make forecasts much more difficult than for the more stable OECD countries.[8]

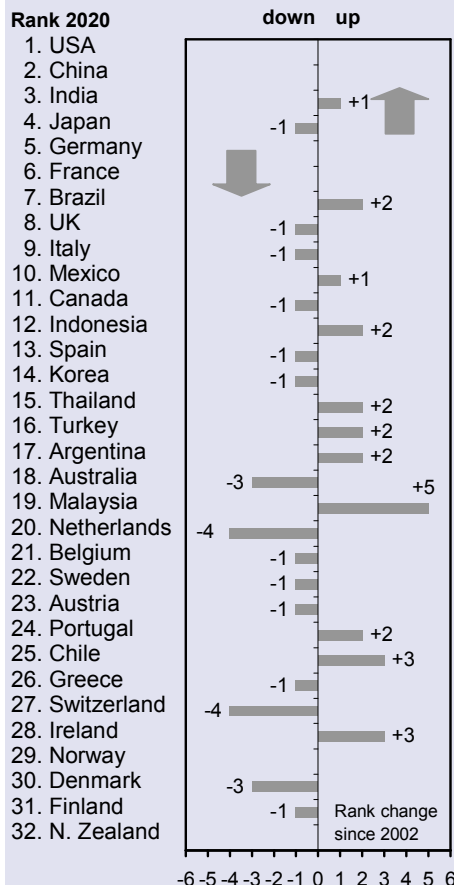### Transparent analytical framework for country forecasts

Formel-G, the growth model of Deutsche Bank Research, combines quantitative and qualitative elements to generate a new transparent

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[6] New research areas cover the subjects of "well-being" and "happiness" in an interdisciplinary approach. The UN Human Development Index works in the same direction.

[7] We only convert with 1995 purchasing power parities. Therefore GDP growth rates in PPP always correspond to GDP growth rates in local currency. We do not factor in changes in the exchange rate and shifts in relative prices over time. The comparisons of levels in years far away from 1995 are thus less reliable. The Penn World Tables use new purchasing power parity exchange rates for each year, so GDP growth rates do not correspond to the rates published by national authorities any more, but the comparison of levels is more reliable for years further away from 1995.

[8] Instead of countries, regions (e.g. South Asia or SaarLorLux) or companies could be topics of research. However, data for units smaller than countries are in many cases not available.

Total GDP level in 2002

USA, China, Japan, India, Germany, France, UK, Italy, Brazil, Russia, Canada, Mexico, Spain, Korea, Indonesia, Australia, Netherlands, S. Africa, Thailand, Turkey, Argentina, Belgium, Sweden, Austria, Switzerland, Malaysia, Greece, Portugal, Denmark, Chile, Norway, Finland, Ireland, N. Zealand

Real, USD bn, 1995 PPP

Sources: OECD, World Bank

Rank change of total GDP

Rank 2020	down	up
1. USA		
2. China		
3. India		+1
4. Japan	-1	
5. Germany		
6. France		
7. Brazil		+2
8. UK	-1	
9. Italy	-1	
10. Mexico		+1
11. Canada	-1	
12. Indonesia		+2
13. Spain	-1	
14. Korea	-1	
15. Thailand		+2
16. Turkey		+2
17. Argentina		+2
18. Australia	-3	+5
19. Malaysia		
20. Netherlands	-4	
21. Belgium	-1	
22. Sweden	-1	
23. Austria	-1	
24. Portugal		+2
25. Chile		+3
26. Greece	-1	
27. Switzerland	-4	
28. Ireland		+3
29. Norway		
30. Denmark	-3	
31. Finland	-1	
32. N. Zealand		

Rank change since 2002
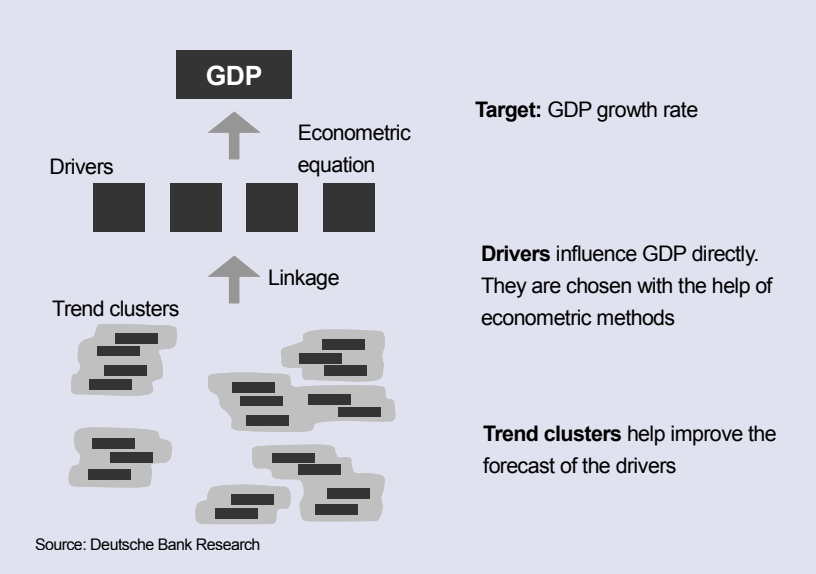
Source: Deutsche Bank Research

analytical framework for forecasts of long-term prospects of national economies. One aim is to help improve the understanding of the fundamental drivers of long-term growth. Lessons from the history of the country and of other countries, as well as new developments in their country-specific intensity are taken into account.

In the first step we identified the most important fundamental **drivers** of growth with the help of modern growth theory and state-of-the-art econometric techniques. We selected four drivers for our model out of the large number of candidates: population growth, the investment ratio, human capital and trade openness. The exhibit shows how the econometric equation links changes in the four drivers to GDP growth.

Step 1: Identify GDP drivers

DBR's analytical framework for long-term growth forecasts: *Formel-G*

Target: GDP growth rate

Drivers influence GDP directly. They are chosen with the help of econometric methods

Trend clusters help improve the forecast of the drivers

Source: Deutsche Bank Research

In the second step we generated forecasts for these drivers until 2020 which were then fed into the empirical model. To ensure a high quality of these forecasts and to capture structural breaks we underpinned them with a broad-based qualitative trend analysis. We analysed the reciprocal effects among a large number of trends and used this information to group them into six coherent **trend clusters**. Then we assessed the past and likely future speed of each trend cluster in each of the 34 economies in our set of countries (page 20). The six trend clusters of our trend map – and their link with the growth drivers – are depicted in the lower part of the exhibit.

Step 2: Forecast drivers with the help of trend analysis

The model forecasts therefore have a broad and solid foundation.[9] However, they are based on assumptions and are subject to the usual limitations of long-term forecasts: assumptions may prove wrong, the impact of the trends might differ, and correlations between growth drivers and GDP (regression coefficients) might change. In particular, countries could tackle more (or fewer) reforms than assumed, which could lead actual growth to diverge from the model forecast. After all, our analytical framework not only offers a checklist for investors but also a to-do list for economic policy on how to achieve a better growth performance than suggested by our model forecast. Therefore, we will review the assumptions and the trend assessments on a regular basis.

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[9] Unfortunately, this approach does not allow any out-of-sample tests of the model which would estimate the model until 1990 and then compare the forecast until 2003 with actual GDP. Data are not available in sufficient time series, and our power of imagination required for a trend analysis starting from 1990 is too limited.

B. Theory and methodology

After the first results have been presented and the analytical framework has been outlined, the next two sections explain the fundamentals of modern theoretical and empirical growth analysis. An important element of *Formel-G* will be derived: the econometric equation.

4. Searching for technological progress

Growth forecasts must have a solid theoretical foundation. The basis of most growth analyses is the **neoclassical production function** in which **output Y** is a function of **labour input L**, **capital input K** and the **level of technology A** (Solow residual; usually called "total factor productivity"). Growth decompositions divide actual growth into these three components. However, over the long-term, the sole driver of any growth of per capita output is the progress of technology A. It also is crucial for the long-term increase in the capital stock per capita.[10] Therefore, forecasts of economic growth with the help of simple growth decompositions require more or less arbitrary assumptions on technological progress.[11] They do not explain the really interesting variable A but bury it in an assumption. Therefore, simple growth decompositions are not suitable for forecasting.

The often assumed **absolute convergence** of income levels between countries (i.e. poor countries' GDP grows faster than rich countries') also lacks theoretical and empirical support. There is no automatism: higher income levels do not fall from heaven like manna but require hard work.[12] GDP of a country only converges to the country-specific income level that is determined by that country's growth drivers.

Therefore, any useful model of the future has to explain technological progress. This is easier said than done, however. Mankiw/Romer/Weil made a pathbreaking contribution in 1992 by incorporating **human capital H** as a measure for the quality of labour input into the empirical growth analysis. Human capital describes a person's ability to produce output efficiently and to develop new products. This important additional variable helped significantly in explaining historic income differences across countries.

For empirical growth analysis, this was a great step forward but not fully satisfactory yet. Both theoretical and empirical work of the last ten years tried to model the remaining, unexplained share of technological change after human capital is taken into consideration. The objective is **to explain** economic growth **as fully as possible in the model** by incorporating a further policy variable P (or several variables). Exogenous, unexplainable influences are to be minimised.

The search for P gave rise to a flourishing literature dealing with the role of politics, institutions, knowledge and innovation.[13] In their overview, Durlauf, Johnson and Temple (2004) identify 42 "growth theories" using a total of 102 variables – which may be combined in different variations.[14] Although theory does not produce a clear conclusion on the "correct" growth model (the "correct" P) it helps us identify potential growth drivers. The decision as to which additional variables really have a statistically and economically significant link with growth will have to be based on econometric analysis.

Theoretical foundation: the production function

Production function in the Solow model:

$$Y_t = K_t^{\alpha} \cdot \left(A_t \cdot L_t \right)^{1-\alpha}$$

Absolute convergence not a given

Production function in the Mankiw/Romer/Weil model:

$$Y_t = K_t^{\alpha} \cdot H_t^{\beta} \cdot \left(\widetilde{A}_t \cdot L_t \right)^{1-\alpha-\beta}$$

Production function in *Formel-G*:

$$Y_t = K_t^{\alpha} \cdot H_t^{\beta} \cdot \left(P_t \cdot \hat{A}_t \cdot L_t \right)^{1-\alpha-\beta}$$

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[10] This is set out very clearly by Barro, Sala-i-Martin (2004), pp. 457 and 460.

[11] For example, filter techniques with averages of the past are applied or absolute convergence with other countries is assumed.

[12] Easterly and Levine (2001) even observe a divergence in income levels.

[13] The World Bank, the IMF, the OECD and the NBER have contributed many new insights with new data sets and a large number of publications.

[14] Temple (1999) also gives an excellent overview.

5. Broad spectrum of empirical growth models[15]

In parallel with growth theory, econometric analysis has made great progress in the last few years. Better and more comprehensive **datasets** for ever longer periods became available and the **econometric techniques** have been improved considerably. State-of-the-art technique these days are panel regressions even though **cross-section regressions** continue to be very popular. In cross-section regressions average annual GDP growth from 1990 to 2000, for example, is explained by the initial level of income in 1990 and the averages of other variables from 1990 to 2000 on (e.g. institutions, openness, inflation, investment etc.). The Bayesian analysis of Fernandez, Ley and Steel (2001) with two million cross-section regressions identifies among others the investment ratio, openness, rule of law and primary education as significant growth drivers. The IMF has even developed a forecasting model using cross-section regressions.[16]

However, the cross-section analysis does not take into account information embedded in the series' time dimension. Therefore we apply a modern panel procedure using annual observations of the various growth drivers in the 32 economies of our group. The first efforts to generate growth forecasts with the help of **panel regressions** were regressions which (with the exception of the constant) estimate equal slope coefficients of variables for all countries (fixed effects). As these assumptions are very restrictive, the alternative approach estimated separate equations for each country and then calculated the averages of the respective slope coefficients (mean group). However, because of the limited number of observations for each country, this procedure is inefficient.

Panel estimate on the basis of pooled mean group technique

The **pooled mean group technique** is a compromise method which assumes the same long-run relationship between the (log) level of the growth drivers and (log) GDP per capita in all countries but allows country-specific convergence coefficients Φ_i, constants $\theta_{0,i}$ and short-term dynamics to take care of the respective economic cycles.[17]

$$\Delta \ln y_{i,t} = -\Phi_i [\ln y_{i,t-1} - \{-\theta_{0,i} + \theta_1 n_{i,t} + \theta_2 \ln i_{i,t} + \theta_3 \ln h_{i,t} + \theta_4 \ln P_{i,t}\}]$$
$$+ \text{ short-term dynamics}$$

In the equation above, y equals per capita GDP of the 15-64 age group, n the percentage change of the population aged 15 to 64, i the investment ratio, h per capita human capital and P the policy variable. The subscripts i and t run across countries and time. The long-term relationship compares the per capita GDP level of the previous period (i.e. t-1) with the current level as explained by the fundamentals (the brace in the formula). The pace at which a potential gap between the two (square bracket) will shrink in the future is determined by country-specific convergence coefficients Φ_i. This procedure has the great advantage that long-term growth in a specific country is not only based on that country's historic experience but also on the estimated average growth-relationship across all countries. This is extremely helpful for our

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[15] The theoretical and empirical analysis was done in close cooperation with Marco Neuhaus. Special thanks also go to Sarah Rupprecht and Susanne Ullrich for their support with econometrics and databases.
[16] Batista and Zalduendo (2004).
[17] Pesaran, Shin, Smith (1999). This approach is also increasingly taking root in other fields such as empirical exchange-rate analysis.

The elements of *Formel-G*

GDP per capita 15-64 (y, dependent variable): difference in the natural logarithm of real GDP in 1995 USD PPP divided by the population aged 15-64

Population 15-64 (n): difference in log levels of the population aged 15-64

Investment (i): log share of real fixed investment in GDP * 100

Human capital (h): log years of education per capita of the population aged 25-64

Openness (P): log trade share corrected for differences in population levels and purchasing power parities

Source: Deutsche Bank Research

Regression results OECD countries

	Coefficient	t-Statistic
Common coefficients		
Population (15-64)	-4.07	-4.8
Investment	0.16	6.9
Human capital	0.82	11.1
Openness	0.39	14.9
Country-specific coefficients (average)		
Convergence	-0.19	-4.1
Constant	1.47	4.2

Regression results emerging markets

	Coefficient	t-Statistic
Common coefficients		
Population (15-64)	-9.55	-3.7
Investment	0.13	2.6
Human capital	0.92	11.9
Openness	0.14	4.7
Country-specific coefficients (average)		
Convergence	-0.17	-2.3
Constant	1.23	2.5

Source: Deutsche Bank Research

The model's fit for the USA
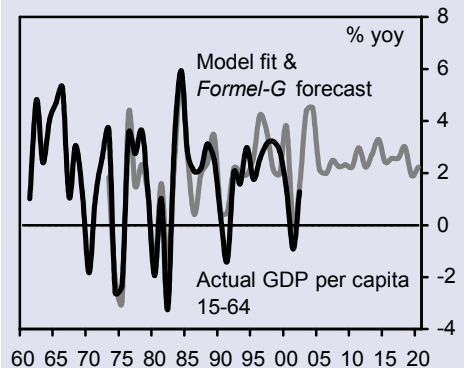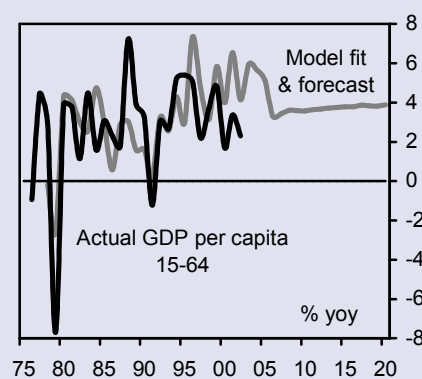

Source: Deutsche Bank Research

purposes as **a forecast for a country should not only be based on its own development over time.** Instead, it is based on a general long-term relationship between changes of drivers and GDP growth across all countries.

The first criterion for incorporating a driver into *Formel-G* is a **stable relationship** across countries, periods and model specifications with economic growth in the **empirical growth literature**. Second, **time series** have to be **available**. And third, our own estimates have to show a **statistically and economically significant relationship**. For 21 OECD countries our estimates with annual data from 1970 to 1998 show a significant long-term relationship between per capita GDP of the 15-64 age group and **population growth**, the **investment ratio**, **human capital** and **openness**.[18] A time trend is not significant, which indicates that our model largely explains technological change. The estimated pace of convergence is relatively high: in most countries, a gap between actual GDP and its fundamental long-term equilibrium is reduced by half within roughly three years. The country-specific short-term dynamics allow a respectable average goodness of fit of 0.65.

Since the structure of the emerging markets strongly differs from the structure of the OECD economies we have estimated a second, separate model for **12 emerging markets**. As the table on the previous page shows, the coefficients are similar to those for the OECD economies, although the precision of the estimates is lower as expected. The long-term impact of a change in openness seems to be smaller in poorer countries than in the OECD economies – openness in the emerging markets rose more strongly in the past, however. Unfortunately, no data on human capital are available for Russia, so we were unable to include it in our regression for the emerging markets. In view of the large differences among the emerging markets and frequent crises in these countries, the econometric results are of course less reliable for forecasting purposes than in the case of the OECD countries. The average measure of the goodness of fit for the emerging markets is also a fairly high 0.65, however.

Our four GDP drivers: population growth, investment ratio, human capital and trade openness

The model's fit for India

Source: Deutsche Bank Research

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[18]   GDP, investment and human capital in logarithmic form. According to the Hausman statistics, long-term coefficients are indeed roughly equal in all countries.

C. Drivers and trends in detail

In the previous sections, we outlined the theoretical framework for our growth analysis and the econometric equations for the two country groups. The next two sections will explain in detail the growth drivers and the trends affecting them and thereby economic growth.

6. Drivers of economic growth

To be incorporated in *Formel-G*, a driver – as outlined in the previous section – must have a solid theoretical and empirical relationship with GDP growth. Population growth, investment, human capital and trade openness meet these criteria and are described in more detail in this section. Other candidate variables did not make it into *Formel-G* for various reasons: either they did not add much new information beyond our four drivers, or the econometric relationship with the growth rate was not clear, or there were not enough historic data. Some of these candidates will also be described below.

Population growth: quantity of labour input

In a large number of our selected countries, population growth accounts for roughly one-third of total future GDP growth and is thus one of the most important fundamental drivers of growth: a rise in **labour input** also leads to higher GDP overall. Of course, this is of secondary importance for the individual citizen. In the first step, our empirical model estimates GDP growth per capita of the 15-64 age group as our measure of productivity. With the help of our population forecasts, all other variables are deduced by simple combination.

For the **historical population development** (overall and of the 15-64 age group) we use the figures of the Groningen Growth and Development Center and the World Bank's World Development Indicators.[19] For the baseline forecast, we use the interpolated UN population growth forecasts of 2002.[20] Certainly, a better measure of actual labour input would be hours worked, which would also account for differences in participation rates and retirement ages. These variables have to be closely monitored in any country analysis, but unfortunately the data are not available for all countries in our group.

According to the **theoretical model**, an increase in the population initially leads to lower GDP per capita as the existing capital stock has to be distributed across a larger number of workers. By contrast, the long-term relationship in our regression equation points more to a demographic function: high-income countries tend to have lower birth rates and lower population growth. The model is of limited help if population growth weakens for other reasons: it cannot know AIDS as a main factor for the population decline in South Africa. Thus model forecasts for South Africa are unfortunately not very reliable and are not discussed below.[21]

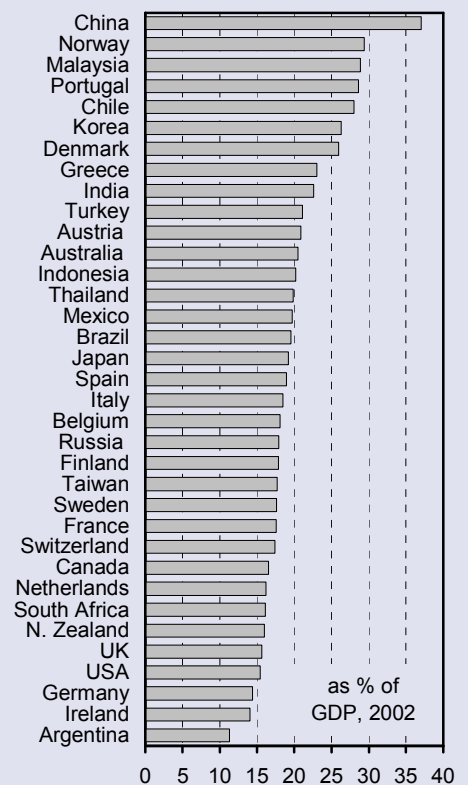**Investment ratio: accumulation of capital**

One of the **classic** drivers of growth is the **investment ratio**, which determines the accumulation of real capital. It is included in every theoretical and empirical model even though the investment ratio cannot rise forever and in view of declining marginal returns does not allow higher GDP growth per capita but only a higher GDP level in the long run. Furthermore, empirical analyses suffer from endogeneity

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[19] www.ggdc.net
[20] Medium variant; www.un.org/esa/population/unpop.htm
[21] *Formel-G* calculates annual GDP growth for South Africa of 4.9%, which partly stems from a solid development of the growth drivers.

DBR's analytical framework for long-term growth forecasts: *Formel-G*
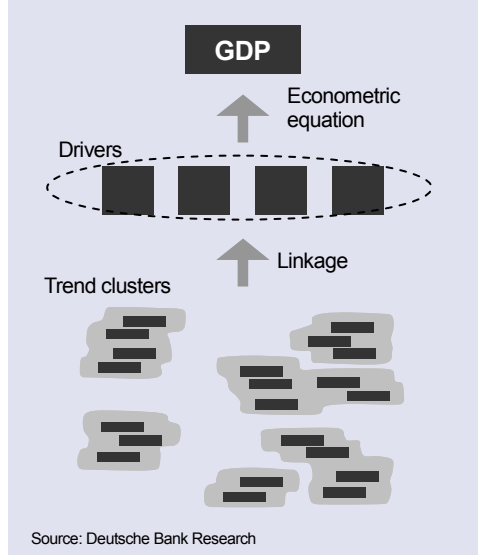
Source: Deutsche Bank Research

Investment ratios in 2002

as % of GDP, 2002

Sources: OECD, World Bank

problems: investment is a function of economic growth in the short run and a function of technological progress in the long run – i.e. the other variables in our model.

For the OECD economies, we use the share of real investment of the corporate sector in real GDP taken from the OECD database. These data are not available for the emerging markets. Therefore we use the share of total investment in real GDP for these countries from the World Bank's database. Over the past decades, investment (or its ultimate determinants) played a major role for economic growth, especially in South Korea and Germany. In South Korea the investment ratio rose from 5% of GDP in the early 1960s to over 35% in the early 1990s. By contrast, in Germany it fell from 25% at the beginning of the 1960s to below 15% in 2002. However, as indicated earlier, investment ratios usually **do not have a long-term time trend**, and therefore can only have a medium-term impact on growth. Our forecasts for the investment ratios therefore make use of the fact that investment ratios only shortly move outside the range between 15% and 30% (see chart). In South Korea, the investment ratio has meanwhile fallen back to 25%. The ratio in China is still close to 40%.

Human capital: quality of labour input

The human brain is one of the major sources of wealth and growth. Non-economists often have reservations with regard to the concept of human capital – on concerns that human beings are only seen under the aspect of economic benefit. However, the importance of education has been recognised and accepted all over the world. Human capital stands for the **quality of labour input**, the ability to combine production factors efficiently and the capacity to absorb and apply new knowledge and to pass it on. This accounts for a major share of technological progress.

The best available yardstick for human capital is the average **number of years of education per capita** of the 25-64 age group, which the OECD calculated back in 2002 for 95 countries for the past and until 2010. This measure takes into account university-level education but does not include professional training.[22] According to this definition, Germany (13.5 years), Switzerland (12.9 years) und Canada (12.9 years) had very high level of human capital in 1998; China (5.8 years) and India (4.1 years) ranked at the lower end (see chart). From 1988 to 1998, Italy, Spain and South Africa made a particularly great leap forward of more than 1 ½ years each. By contrast, almost no progress was registered in the US, Denmark and recently Germany. Since we look at the average stock of human capital of the 25-64 age group, the number of years of education shows a rather stable development. This facilitates forecasts.

Of course, our measure of human capital is not a perfect measure. For example, years of education in different countries may show extremely strong differences in quality. However, the years of education are usually positively correlated with **quality measures** such as those from the Programme for International Student Assessment (PISA) or the Hanushek/Kim measure (1995).[23] The mathematical proficiency of today's pupils according to the PISA programme 2000 and the average years of education of the working-age population have a correlation coefficient of 0.67 (see chart on the next page). Looking at the measures available, the quality of school education in Germany, the US and Chile is unusually low – relative to the high education level of the

Investment ratios usually between 15% and 30%

Sources: World Bank, Deutsche Bank Research
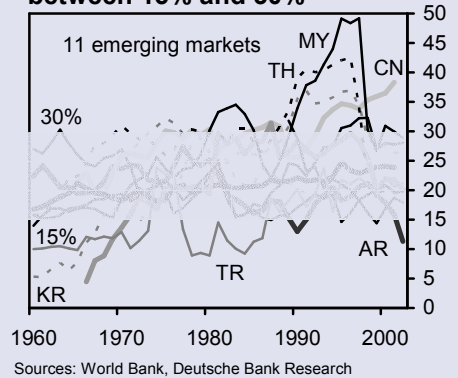
Average years of education of the working population

Source: OECD

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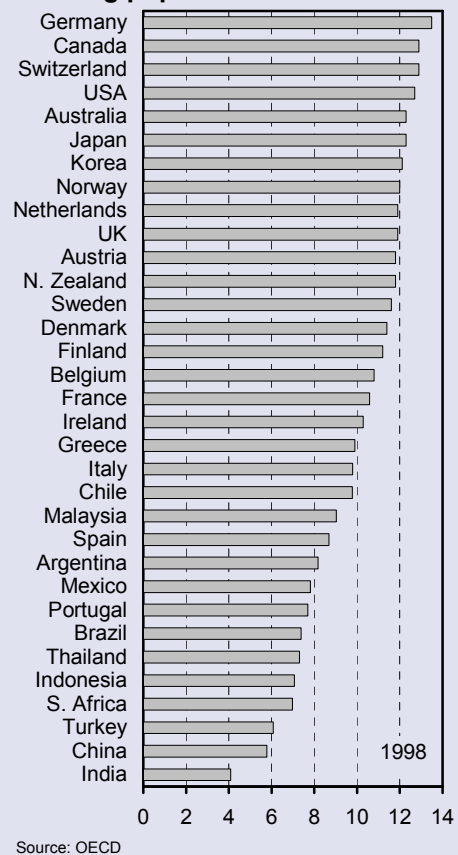
[22] This measure is based on de la Fuente and Domenech (2000) and has been used by Bassanini and Scarpetta (2001) in panel analyses.

[23] Hanushek and Kim (1995).

parents' generation – while it is very high in China, New Zealand and Japan. The positive correlation between the quantity and quality of human capital is likely to also hold for those of working-age today. Another caveat is that education years do not factor in vocational and further private education. However, these have probably been of minor importance so far and may also correlate positively with the number of years of education. Another complicating aspect is that human capital probably improves also when the number of education years stays the same but the teaching methods and curricula get better and the latest academic findings are imparted.

For our GDP forecasts we use average years of education as the best available proxy for human capital and we also factor professional training in the forecast, which will not be taken into account in the officially recorded number of education years.

The **empirical correlation** between education and income is unequivocally positive. Microeconomic analyses regularly explain much of the difference in income between people with differences in the levels of education. What applies to individuals also applies to entire economies. Our panel estimate finds a statistically significant relation-ship between the level of human capital and the level of GDP for both the OECD countries and the emerging markets. The size of the coefficient is consistent with estimates generated by the OECD:[24] in the long run a 10% increase in the number of years of education results in an 8% increase in per capita GDP in the OECD countries and a 9% increase in the emerging markets. In Germany, 10% would today translate to an additional 1.4 years, and in China to 0.6 years. In our model, human capital – along with openness – is the key driver of economic growth over the long run. These two drivers will therefore be examined in greater detail in follow-up studies.

Trade openness promotes learning[25]

If a country trades more with other countries, then the competitive pressure on companies and the state increases, leading to efficiency gains and a higher production potential.[26] In addition, the country can benefit from technological progress embodied in imported capital goods. Economies of scale in production may be realised. With the same amount of human capital (as defined above) more output can be produced. In standard neoclassical models of comparative advantage, trade increases the consumption possibilities of the population, but real GDP does not grow as the production potential of the economy does not change.

Our **measure of the openness** of a country is based on the average of the shares of imports and exports in gross domestic product. We adjust this foreign trade share using purchasing power parity exchange rates in order to correct for the differences between the domestic price level of non-tradeable goods and the world market prices of exports and imports.[27] With the exceptionally high domestic price level in Japan the country's national accounts, for example, report a lower foreign trade share than at the average prices of the other countries. The exact opposite can be observed in China, where domestic prices are still relatively low. Since small countries conduct more foreign trade than

Education: quantity & quality

Sources: OECD, Deutsche Bank Research

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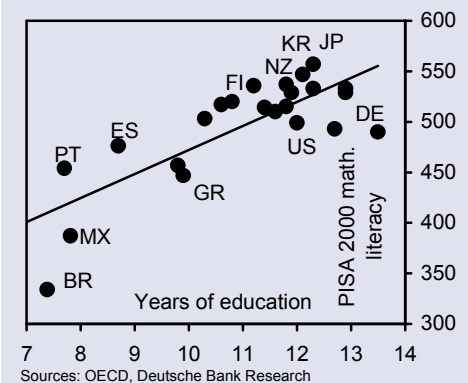
[24] Bassanini et al. (2001).
[25] The forthcoming study by Marco Neuhaus will analyse in more detail the various measures of openness and the reasons for the particularly vigorous opening of individual countries.
[26] See, for example, Frankel and Romer (1999) and Baldwin (2003).
[27] Similar to Alcala and Ciccone (2003).

large countries we make a further adjustment to the purchasing power parity foreign trade share using the size of the country's population.[28]

Trade openness as measured with our approach has been on an **uptrend** for all countries during the last decades. The most open economies in 2002 were Germany, Belgium, the Netherlands and France – all at the centre of Europe and founding members of the EU. The most closed economies were Argentina, South Africa and New Zealand (see chart). Mexico, India and Turkey opened their economies most rapidly during the last 10 years. Among the OECD countries Spain and Ireland have opened up particularly fast.

Our empirical analysis finds a significant **positive link between the degree of openness and the level of GDP**, with the coefficient in the OECD countries more than twice as high as in the emerging markets. Between 1992 and 2002 our openness measure for the OECD countries has risen by 0.35 points, which pushed up average per capita GDP by 14% according to our empirical model. According to the estimates for the emerging markets, per capita GDP in India would be 10% higher in the long term, if India were to achieve the current openness level of China.

Other measures of openness take into account capital mobility (e.g. direct investment), the level of tariffs or non-tariff trade barriers. However, in our view these measures are less suitable for our growth model than our openness measure as they do not capture the bilateral relationship with other countries as accurately. Many of the other measures also show a significant positive correlation with our measure.

Apart from these four drivers there are, as mentioned above, dozens of other drivers of growth used in empirical analysis. For a variety of reasons they have, however, not made it into our empirical model. Nevertheless, we will discuss some of them briefly here:
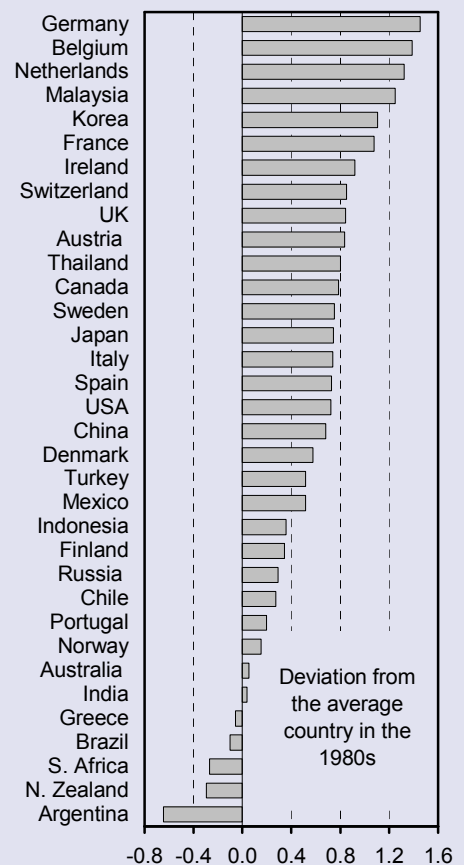
Innovation, research and development

Spending on research and development (R&D) is an obvious candidate to explain technological progress. However, it does not make it into our model because it is **positively correlated with human capital**, and because long-term time series are not available. With the outliers of Finland and Sweden high R&D spending as a percentage of GDP is accompanied by a high level of human capital (see chart). For these countries time series data on R&D spending would probably yield only minimal additional information. It is hardly a surprise that spending on both R&D and education are goals of the EU's Lisbon agenda.[29]

In addition, openness can be a partial substitute for domestic R&D spending: Via trade or direct investment a country can gain access to technology from abroad – usually at a cost. There is a global knowledge base, which is disseminating more quickly with improved information technologies. However, the user country must also be in a position to apply this knowledge by first investing in education itself.
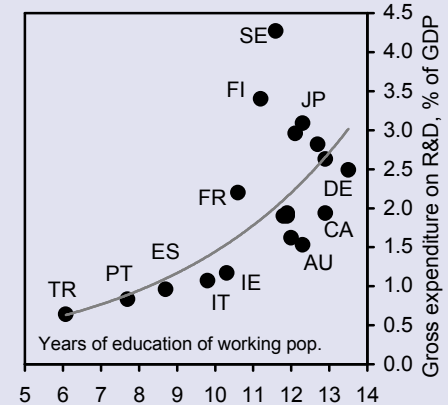
Government influence and the political environment

Decisions taken by the state undoubtedly have a major impact on economic growth. However, there are no time series that fulfil all our criteria for inclusion in the model. For example, overall there is no clear theoretical or empirical relationship between **government spending** and growth. State infrastructure investment, education spending and

Openness 2000-02 average

Germany, Belgium, Netherlands, Malaysia, Korea, France, Ireland, Switzerland, UK, Austria, Thailand, Canada, Sweden, Japan, Italy, Spain, USA, China, Denmark, Turkey, Mexico, Indonesia, Finland, Russia, Chile, Portugal, Norway, Australia, India, Greece, Brazil, S. Africa, N. Zealand, Argentina

Deviation from the average country in the 1980s

-0.8 -0.4 0.0 0.4 0.8 1.2 1.6

Source: Deutsche Bank Research

Education & research correlate

SE, FI, JP, FR, DE, ES, CA, AU, TR, PT, IT, IE

Years of education of working pop.

Gross expenditure on R&D, % of GDP

5 6 7 8 9 10 11 12 13 14

Source: Deutsche Bank Research

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[28] Our panel regression of the log foreign trade shares on the log population size yielded a regression coefficient of -0.44 for the population, with a t-statistic of -32.4.

[29] Chen and Dahlman (2004) also clearly established the correlation between education and R&D .

social peace promoted by transfer payments generally have a positive impact on income levels and possibly even on growth rates. By contrast, early retirement programmes and subsidies for sunset industries have a negative impact. The Scandinavian economies show that high government spending can be accompanied by high growth rates. There may be a country-specific, optimal ratio of total government spending to GDP.

The central task of the state is to provide a **liberal framework** (rule of law) for private activities to be pursued. There is a clearly positive correlation between the level of various measures of economic freedom and the level of per capita income. The chart shows the Heritage Foundation's Index, while the Fraser, World Bank and Freedom House versions show similar correlations. However, in our model, changes in economic freedom already impact growth indirectly via the investment ratio, human capital formation and openness. In fact, there is a particularly high correlation between human capital and the freedom index, as shown in the chart below. Whether there is an additional direct impact of freedom on growth over and above that on human capital is something we cannot test empirically, as there are no long-term time series for the freedom indices. In addition, changes in freedom are particularly difficult to forecast. However, many of our trends which feed into the forecasts take into account perceived changes in freedom and thus model the impact on the drivers.

Whether the **political system** has an impact on growth, remains unclear. Economic growth has often picked up after the political system in a country has become more autocratic. Whether for example greater democracy in China would lead to higher growth cannot be answered empirically.

Price stability has a positive impact on the income level since planning can be made on the basis of more reliable parameters. The OECD countries have had price stability for many years now, so (assuming that price stability is also maintained in future) our forecasts would not change, if we were to include the inflation rate in the model. Many emerging markets have this income-boosting step still ahead of them. However, given the high volatility in the past it is very difficult to forecast when they will achieve this.

Financial system: select the most efficient projects

It is easy to see that theoretically **more efficient financial systems** boost economic growth: the savings of private households and from abroad flow into more efficient projects with higher returns. Risks are diversified more efficiently and riskier (higher return) projects are pursued. The investment ratio would rise at least in the medium term. Bekaert, Harvey and Lundblad (2001) conclude that financial market liberalisation boosts growth by 1% over 5 years. However, all countries in our group apart from China have liberalised financial markets, according to their definition.

Unfortunately, it is very **difficult to define exactly**, what constitutes an "efficient" financial system. It is even more difficult to find good measures with the appropriate history. Stock market capitalisation as a percentage of GDP is often used as measure of the efficiency of a financial market. However, the high market capitalisation in Japan at the start of the 1990s was not followed by high growth in subsequent years. That is a reason why we have not incorporated stock market capitalisation into the model.[30]

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[30]   A detailed literature overview is supplied by Ross Levine (2004) .
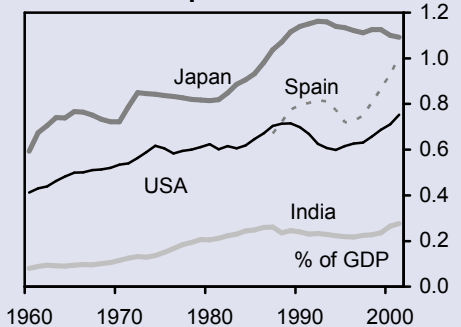
GDP/capita vs Index of Freedom
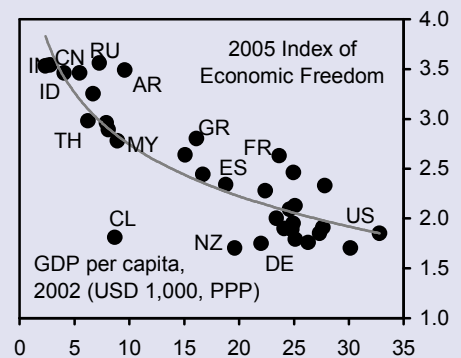
Sources: Heritage Foundation, Deutsche Bank Research

Education vs Index of Freedom
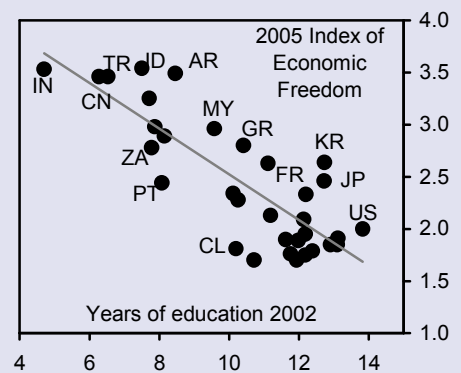
Sources: Heritage Foundation, OECD, DBR

Loans to the private sector

Source: Deutsche Bank Research

Nor must a large portfolio of **bank loans as a percentage of** GDP always have a positive impact on growth. A bank-based financial system may be suitable for less advanced countries where there is less uncertainty about profitable investment projects. By contrast, leading countries with rapid technological progress may require a capital market-based system in which risk diversification and monitoring is performed by many participants.

Because of the **measurement problems** and the **unstable statistical relationships,** no financial market variables are incorporated into our model, even though changes to the financial system will undoubtedly have a significant impact on economic growth in many countries. This clearly illustrates once again the importance of a comprehensive country analysis that pays particular attention to the development of the financial system.

Others: religion, geography

Apart from the above mentioned drivers there is a multitude of other constant or time-varying variables, which have been regarded as relevant for growth in parts of the literature. Many studies conclude, for example, that Confucianism has a positive impact on growth. However, as Confucius lived as long ago as 6 BC, one needs to ask why Asia has not been by far the richest region for centuries. In fact, these studies simply examine the otherwise unexplained components of the strong growth of the Asian tigers in the last decades. Deriving a causal link from this is just as inadvisable as doing the same from, for example, the latitude or the climate of a country's capital.

7. Forecasting the drivers

The four drivers in our econometric model thus are population growth, the investment ratio, human capital and openness. For these four time series we require forecasts up until 2020 that can subsequently be fed into the econometric equation. We have developed a three-stage process to do this:

Forecasting the GDP drivers until 2020

-   In the **first stage (extrapolation)** it is the past development alone that determines the future course of each time series. For all 34 countries three drivers were extrapolated with the help of the respective best, and in some cases non-linear, time series procedure. The exception is population growth, for which we use the United Nation's forecasts as our baseline.

Stage 1: extrapolation

-   The **second stage (cross-check)** factors in additional information from the historic and future developments in the other countries. In some cases the extrapolation results in levels or changes in the time series that differ starkly from those of other countries in the past and the future. We have systematically corrected these paths with the help of information from averages and changes from the other countries in order to dampen extreme projections. This stage was only required for the investment ratio and human capital; extrapolation of the openness measure produced no extreme developments for any country. We call the outcome of the first two stages "the baseline forecast".

Stage 2: cross-check

-   The **third stage (trend analysis)** is by far the most complex and is a key element of the entire project. It is applied to all four drivers. This innovative stage is designed to increase the reliability of the forecasts and help to recognise and model structural breaks. In this stage we assess a broad range of information that is not contained in the extrapolating baseline forecast or other growth models. Internal and external knowledge from trend and future research about the individual countries can thus be systematically incorporated into the forecast. In our opinion, this trend analysis

Stage 3: trend analysis

helps to make the forecasts of the drivers significantly more reliable.

Trend analysis with a broad spectrum of information

In an ongoing process Deutsche Bank Research monitors more than 40 trends from the five following categories: "The individual and society", "Institutions and political environment", "Organisational forms and markets", "Innovation and technology", and "Natural resources". For the global growth centres project we have selected those **21 trends** that are likely to be particularly significant **for future economic growth**. Further selection criteria were a good understanding of the fundamental causes and reasons for the trend; robust evidence for the existence of the trend; sufficient breadth of the trend; and relevance in the coming 15 years.

In order to reduce the complexity of the model we first assessed the reciprocal effects among all the trends with respect to strength and direction in a 21x21 cross-impact matrix.[31] Based on this information we then combined the individual trends by means of a **cluster analysis** (average linkage method) into 6 consistent trend clusters that are illustrated on the map on page 21.[32] Trends within a cluster pull in the same direction relative to other clusters; trends in clusters that are far apart may impede each other.[33] An important advantage of this approach is that information about the development of one trend can simultaneously supply information about the other trends in the same cluster.

With the aid of a multitude of **indicators** that supply information about both the level of and the changes in the various trends, we have examined how fast these trend clusters have developed in the last 10 to 15 years in the 34 countries. Then, using these indicators and the country knowledge of DBR we have constructed a forecast about the likely speed of the trend clusters during the forecast period until 2020. The decisive impact on our growth forecasts will come from the **changes in the speed** of the trend clusters over time – their acceleration. If a trend cluster develops just as quickly in the future as in the past, then it provides no additional information beyond the simple extrapolation in our baseline forecast. If the speed changes, the drivers will also develop differently – and GDP growth will change. For a number of emerging markets we have also factored in additional structural breaks that have been identified by our country experts: Turkey's bid to join the EU and the increasing political stability in Brazil will have an impact that our trend clusters cannot fully reflect.

The next section gives a very brief introduction to the six trend clusters, the specific trend profile in some of the 34 countries in the last 10 to 15 years, the likely profile in the next 10 to 15 years, as well as the relevance of the clusters for the four drivers of our model and thus for the model-based forecast. We shall describe the trend clusters in greater detail in follow-up studies in the coming months.

Systematic selection of the trends that will shape future growth

21 trends grouped into 6 consistent trend clusters

Speed of the trend clusters can change

Source: Deutsche Bank Research

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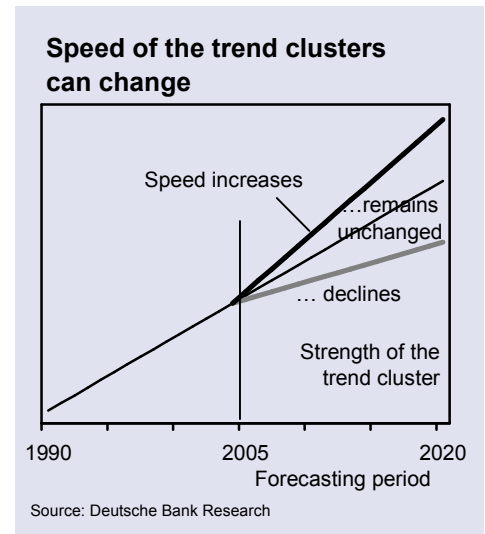
[31] In an iterative process we have given each cell of this matrix an integer between -3 and +3 which indicates the sign and degree of influence of the trend on the y-axis on the trend on the x-axis.

[32] Jan Hofmann will explain the methodology more precisely in a follow-up study and describe a trend cluster in detail. Subsequent follow-up studies by Hofmann, Rollwagen, Neuhaus and Bergheim will shed light on the other clusters.

[33] Neighbouring trend clusters can move together as there are close links between some trends that cross cluster boundaries.

8. DB Research's six trend clusters

Opening of work and society

The trend cluster "Opening of work and society" refers to the ongoing process in which the rigid structures inherent in labour markets and societies are being dismantled, flexibility is increasing and more people are being integrated into the economy. Career paths and working environments are becoming more flexible, so the practice of doing the same job for the same employer for one's whole working life is becoming less important, making lifelong learning more important and resulting in more frequent changes of job duties and employers. Women gain more importance in employment, because more women are working and they are assuming positions with greater responsibility. We regard the city as the most efficient location in the knowledge-based society, providing the infrastructure that enables career (apart from agriculture and the skilled trades) and family to be combined: urbanisation is rising (see chart). The city is also the first port of call for the increasing number of labour migrants from other countries.

In Scandinavia this trend cluster has developed particularly rapidly over the last 10 to 15 years: labour markets have become much more flexible and the employment rate for women has reached record levels, also compared to the employment rate for men (see chart). We expect these trends to continue there at a similar pace in future. The most pronounced acceleration in the opening of work and society in the next 10 to 15 years is likely to occur in Germany, Italy and Japan – Japan and Italy in particular have been very closed societies to date, but they are under considerable pressure to change. In Germany the significance of these trends appears to have been recognised already and a great deal of effort is being put into effecting changes. In the emerging markets the trend has been particularly strong in the past in Malaysia and Turkey. We expect the highest acceleration in the trend to come in India, China and Turkey.

Impact on the drivers. Countries in which the trend cluster will develop faster than in the past should – in our opinion – exhibit a lower population growth than those where the speed of the trend remains unchanged, since the opportunity cost of bringing up children (salary foregone) is rising. More flexible labour markets also allow a higher investment ratio, because among other things higher labour input boosts the return on capital. We assume that the opening of work will also positively impact the development of human capital (including lifelong learning), as more and more people will be able to obtain greater returns on their education. Migration across national borders should help to foster open trading relations with foreign countries.

Enlarging scope of life

The trend cluster "Enlarging scope of life" consists of two trends that clearly belong together: ageing populations and the expansion of the healthcare sector. The healthcare sector offers superior goods for which demand rises more than proportionally with income. It encompasses both the treatment of acute ailments as well as preventive measures and expenditure on conditions for which there is no medical indication such as cosmetic surgery. We regard the rapid pace of technological progress as another key driver of this trend.
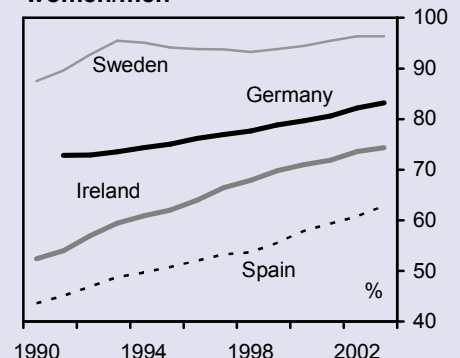
DBR's analytical framework for long-term growth forecasts
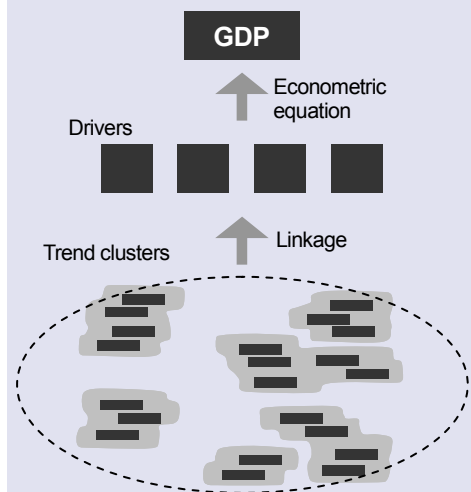
Source: Deutsche Bank Research
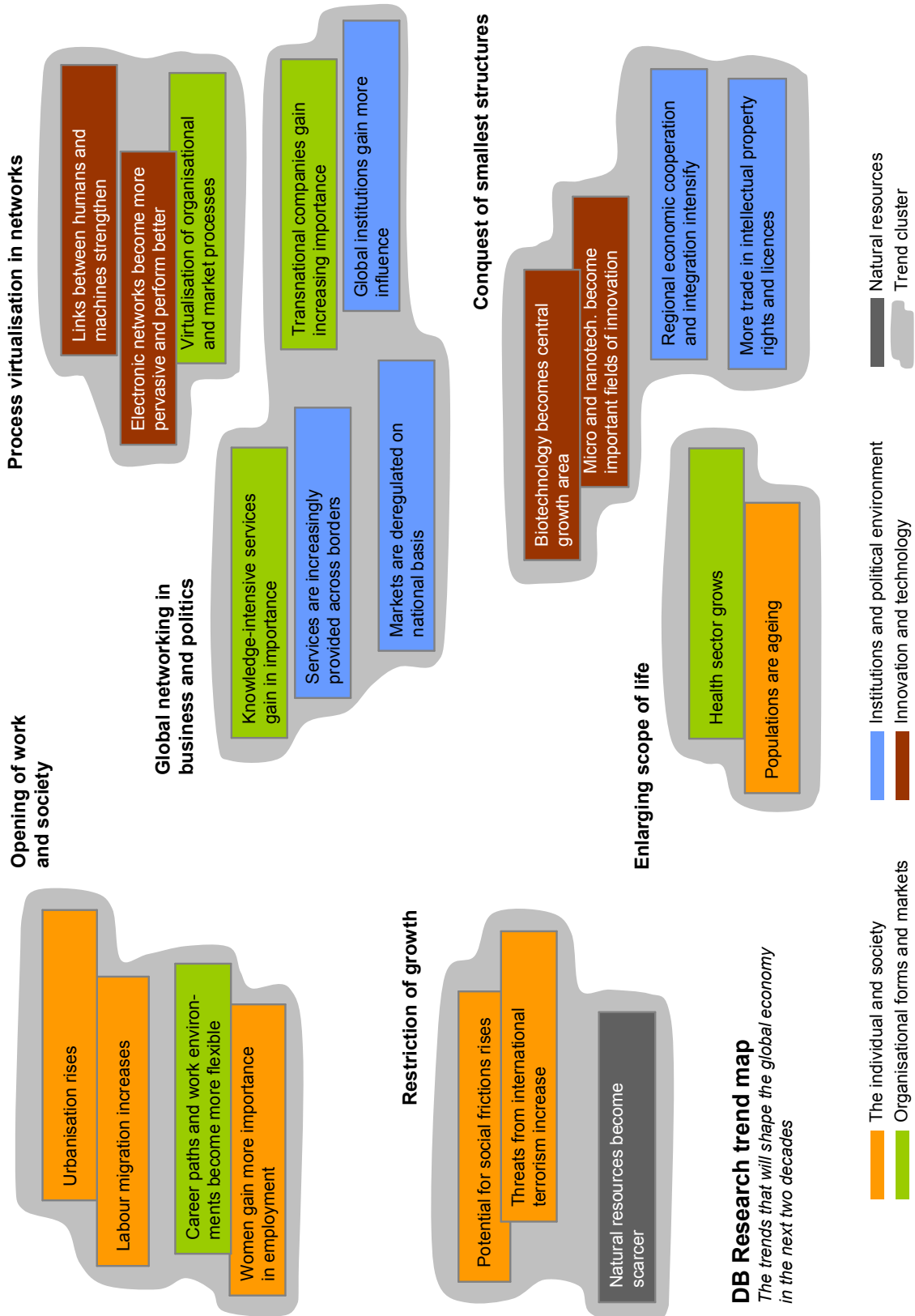
Share of urban population
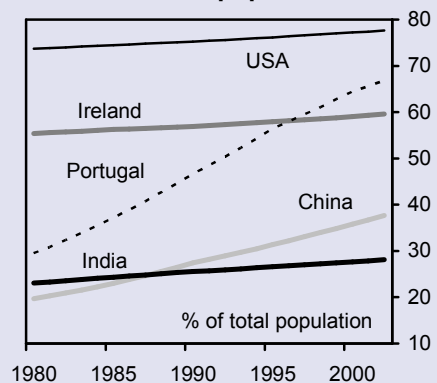
Source: World Bank

Ratio of participation rates women/men

Sources: Eurostat, Deutsche Bank Research

DBR trend map

Process virtualisation in networks

- Links between humans and machines strengthen
- Electronic networks become more pervasive and perform better
- Virtualisation of organisational and market processes

- Transnational companies gain increasing importance
- Global institutions gain more influence

Conquest of smallest structures

- Biotechnology becomes central growth area
- Micro and nanotech. become important fields of innovation

- Regional economic cooperation and integration intensify
- More trade in intellectual property rights and licences

Natural resources

Trend cluster

Opening of work and society

Global networking in business and politics

- Knowledge-intensive services gain in importance
- Services are increasingly provided across borders
- Markets are deregulated on national basis

Enlarging scope of life

- Health sector grows
- Populations are ageing

Institutions and political environment

Innovation and technology

- Urbanisation rises
- Labour migration increases
- Career paths and work environments become more flexible
- Women gain more importance in employment

Restriction of growth

- Potential for social frictions rises
- Threats from international terrorism increase
- Natural resources become scarcer

DB Research trend map
The trends that will shape the global economy in the next two decades

The individual and society

Organisational forms and markets

Many goods and services in the health sector increase life expectancy. We therefore believe that the average age of the population will rise even faster than assumed in most official projections. One of the indicators we use, median age, is depicted in the adjacent chart. For example, according to UN projections, the median age in India will rise from 24.5 years at present to 31.9 years by 2030 despite the high birth rate. This trend cluster has been particularly strong in the past 10 to 15 years in Japan, Switzerland, South Korea and Taiwan. Life expectancy and healthcare spending have risen particularly sharply in these countries. The most marked acceleration of the trend cluster is expected in the coming years in the emerging markets India and South Africa. There the governments have recognised the importance of the healthcare sector (parts of which have been severely neglected) for prosperity and growth and have already increased spending.

Impact on the drivers. An acceleration of the "Enlarging scope of life" trend cluster gives a strong boost to population growth by raising life expectancy. To a large extent, this cluster has already been factored into the UN's population projection. However, the latter relies heavily on extrapolation and does not take structural breaks into account. We expect a slightly positive impact of an acceleration of the trend cluster on investment, since the healthcare sector is becoming increasingly capital intensive.[34] Human capital and openness will also improve faster as education and training will become increasingly important with rising life expectancy and because older societies will possibly cooperate more closely with younger societies.

Conquest of smallest structures

The trend cluster "Conquest of smallest structures" comprises two technological and two institutional trends. Biotechnology will, in our opinion, become a major growth area, while microtechnology and nanotechnology become important areas of innovation. In addition, work on and with ever smaller components will tend to be promoted in many regions by better institutions. Regional economic cooperation and integration will also become closer and facilitate research and development in these sectors. Knowledge and intellectual property from these and other sectors will increasingly be traded between companies and research institutions, nationally as well as internationally.

This relatively new trend cluster (originally labelled the "new Kondratieff") has developed particularly fast over the last 10 to 15 years in the US, Germany, the UK and Sweden. For example, government research expenditure on nanotechnology has risen from almost nil to a relatively high level there, the market for venture capital in the biotech segment has developed quickly (see chart), a lot of biotech patents are being filed, and many patents and licences are being traded across borders. In the future, too, we expect particularly rapid developments in the US and Germany, among other things because the size of the market and of the research location will be positive factors. Together with Switzerland these countries should see the strongest acceleration in the trend. In the emerging markets this trend is just commencing. Korea, Malaysia and Taiwan appear to be particularly well positioned.

Impact on the drivers. This trend cluster impacts positively on the investment ratio as research and production in the biotech and nano segments are relatively capital intensive. We believe the trend cluster will also have a positive impact on human capital and openness.

Median age rises strongly

Source: United Nations

Risk capital: biotechnology

Per million GDP units

Source: OECD

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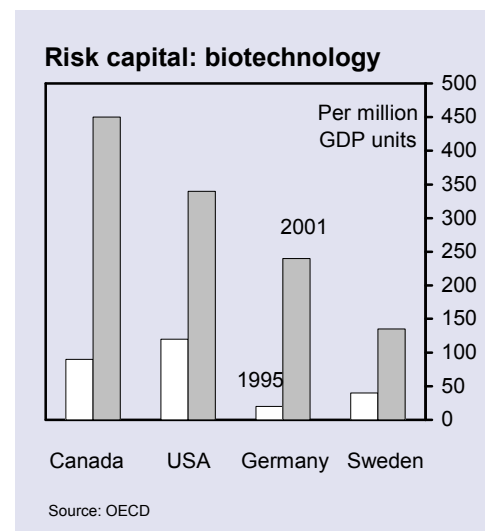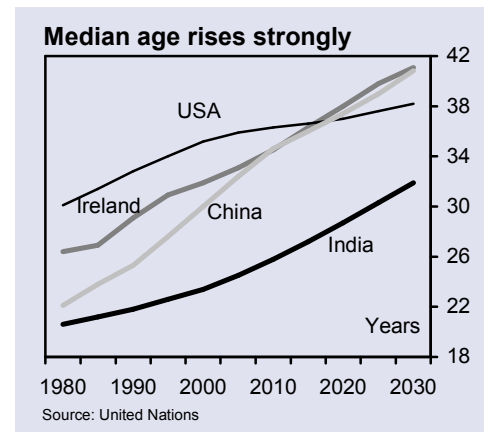
[34] There are, however, also studies which indicate a negative correlation between median age and investment ratio.

Global networking in business and politics

The cluster "Global networking in business and politics" comprises five trends from the institutions and markets categories. More and more market participants are becoming globally active, they will enter new sectors and encounter fewer and fewer state regulations worldwide. This will provide them with more opportunities to escape the rigid structures in their home countries. The importance of transnational companies of all sizes will grow, as will the influence of global institutions such as the IMF, the WTO and non-governmental organisations such as Greenpeace. Knowledge-intensive services will gain importance and these services will increasingly be provided across borders. In order to facilitate this, national product, labour and capital markets will be deregulated.

In the past this trend cluster developed particularly vigorously in Sweden, Malaysia and the Netherlands. There the proportion of exports generated with services has risen particularly sharply. The chart on the right shows the development in four of our growth centres. In addition, labour and goods markets have been deregulated particularly extensively. In the next 10 to 15 years we expect the biggest changes to occur in China, India and Germany. In these countries there is still a great deal of scope for deregulation and the pressure to take action is immense. In China the share of GDP generated by services is still very small. In Germany we expect considerable progress to be made towards establishing a knowledge-based society.

Impact on the drivers. The "Global networking in business and politics" cluster has in our view a distinctly positive impact on human capital as education is necessary to participate in these trends. Openness also increases much faster in countries where these trends become more pronounced than in societies where the intensity of the trends remains unchanged. By contrast, the cluster has no impact on population growth and only a limited positive impact on the investment ratio, as deregulation barely alters relative factor prices.

Process virtualisation in networks

"Process virtualisation in networks" will become more and more important in the coming years. It will bring together more and more participants via increasingly efficient channels; organisational and market processes will increasingly operate in the virtual space. Electronic networking is improving and becoming more widespread, enabling the virtual operation of ever faster and more complex processes. The links between humans and machines strengthen via more intelligent interfaces and will ensure that this complexity does not overwhelm us.

These relatively new trends have only emerged in the last 10 to 15 years. The US led the way, followed by the UK and the Scandinavian countries (see chart showing the sharp rise in the number of internet users). In the future, too, the US will – in our opinion – continue to be the most rigorous in pursuing this course. In Spain, Germany and Japan the trend cluster is likely to accelerate appreciably. Since these trends are very new it is difficult to identify the differences across the individual emerging markets. Many Asian countries, however, seem to be making significant progress.

Impact on the drivers. We assume that the investment ratio will rise, not least because the required infrastructure has to be built. Human capital should improve more strongly, as education and training will be facilitated by the new channels as well as experiencing increased market demand. Networking and virtualisation will also facilitate cross-border exchanges.

Share of services in exports

Source: World Bank

More internet users

Source: World Bank

Income inequality: Gini coefficient

Source: World Bank
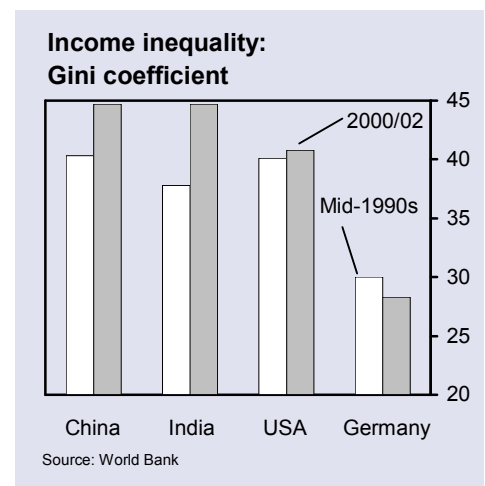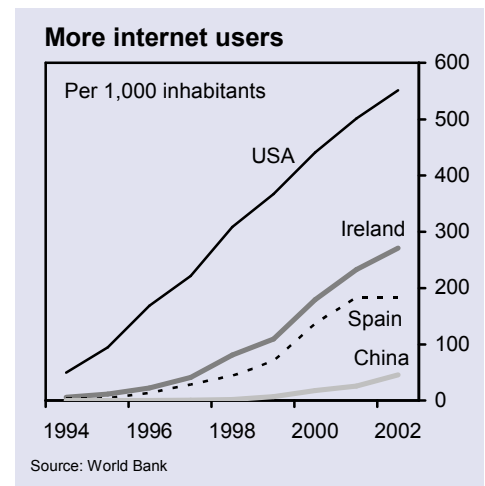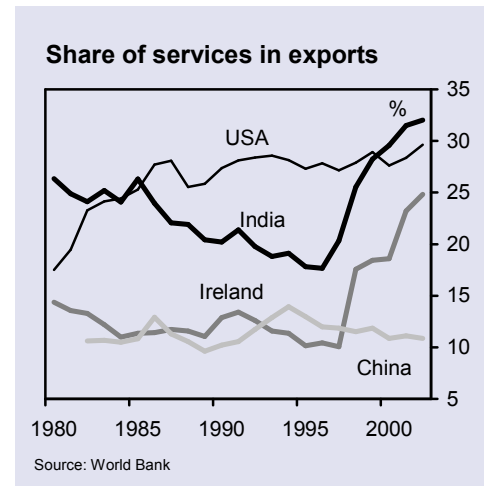
Restriction of growth

The "Restriction of growth" cluster comprises all those trends that tend to put a brake on growth. They often exacerbate one another and hinder some of the other trends or their positive impact on economic growth. The potential for social frictions rises when income differentials widen or ethnic and religious tensions intensify (the chart on the previous page shows the Gini coefficient, one of the indicators we use). The threat from international terrorism is growing and leading to higher spending on security. This ties up resources that could be deployed more productively elsewhere. Natural resources like fossil fuels, clean air and water are becoming increasingly scarce. Fossil fuels are likely to become much more expensive during the forecast period. Sustainable and environmentally-oriented development will become increasingly important.

The rise in energy prices applies worldwide. However, the impact on economic growth will vary from country to country – depending on their level of energy efficiency and net energy import ratio (see chart). Therefore, we need to treat this trend and its impact on GDP growth of individual countries differently from the other trends and link it directly to per capita economic growth. In Korea and Belgium GDP growth will be hit hardest by rising energy prices owing to their high net energy import ratios, whereas Norway, Australia, Mexico and Argentina will be net beneficiaries as energy exporters.

The combination of the two other trends in this cluster (social frictions and terrorism) is treated just like the other five clusters. In the past 10 to 15 years these trends have been particularly pronounced in the US, Italy, Russia and Indonesia. Both the inequality of incomes and the threat of international terrorism have increased substantially in these countries for example. We expect that this cluster will accelerate appreciably for different country-specific reasons in Germany, the UK and Italy. In Russia and India, by contrast, it should be less of a curb on growth.

Impact on the drivers. An acceleration in the trends "Potential for social frictions rises" and "Threats from international terrorism increase" negatively impacts population growth and investment ratios as these countries become less attractive for people and capital. These countries will also open themselves up less to foreign countries than if the speed of the trend were to remain the same as in the past.

Trend-based adjustment of the baseline forecasts

In order to quantify the impact of the change in the speed of a trend cluster on the four drivers we have developed standardised multipliers for all countries in order to calculate a reasonable add-on to the baseline forecast. What constitutes "reasonable" is assessed relative to the average level of the drivers in 2002, as well as to their average increase in the past and their variance across countries. For example, we add 0.8 years of education in 2020 to all countries if the trend speed of the cluster "Opening of work and society" accelerates from "high" to "very high". In the years preceding 2020 the add-on is applied on a pro rata basis. This approach allows only one structural break today and no further changes in speed during the forecast period (see also chart on speed changes on page 19).

In some emerging markets our country analysts expect **significant structural breaks** that are not factored into our general framework. The prospect of accession to the EU will reduce the hitherto high volatility of institutions and inflation rates in Turkey. For Brazil we also expect a structural break towards much more stable domestic institutions, the scale of which cannot be factored into our trend analysis. Therefore, the investment ratio and trade openness should rise much faster in both countries than when these structural breaks are

DBR's energy dependence index

Points, 2001
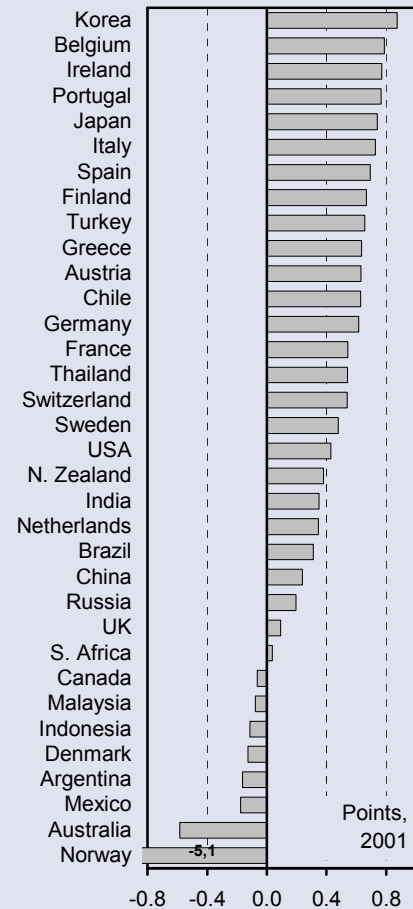
Source: Deutsche Bank Research
Index elements: energy efficiency and net energy imports

Human capital in India: add-on from trends

Years of education per capita

DBR forecast

OECD forecast

2020: + 1.1 years
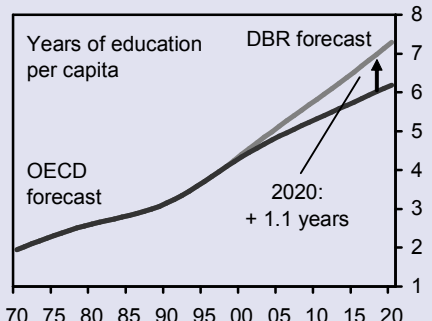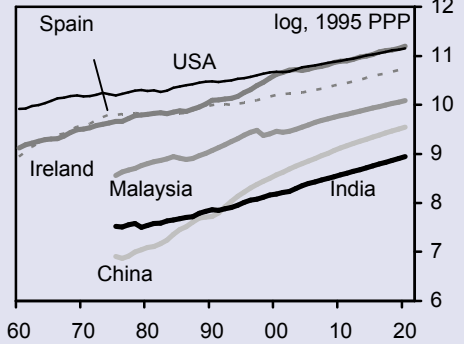
Sources: OECD, Deutsche Bank Research

not taken into account. Our country analysts also expect China to open up even more actively than assumed in our trend analysis: they expect the increase in openness during the last five years to continue at a similar pace.

The **cumulative add-ons** resulting from our analysis of the six trend clusters in the 34 countries are depicted in the charts on this and the following pages. For example, human capital in Germany, Japan, India and China should improve by almost one year more than in the baseline forecast between 2005 and 2020. In Germany and Japan the main reasons are the expected acceleration of the trend clusters "Opening of work and society" and "Process virtualisation in networks", whereas in India and China the acceleration of "Global networking" is the main factor that is boosting incentives for training.

At the final stage the forecasts for the four drivers are fed into the **econometric model**. This calculates annual growth rates for GDP per capita for the 15 to 64 age group until 2020. Using our own population forecasts for both this group and the population as a whole enables the calculation of the levels and growth rates of GDP overall and GDP per capita.

GDP per capita of population aged 15-64

Source: Deutsche Bank Research

GDP growth 2006-20: impact of the trend clusters
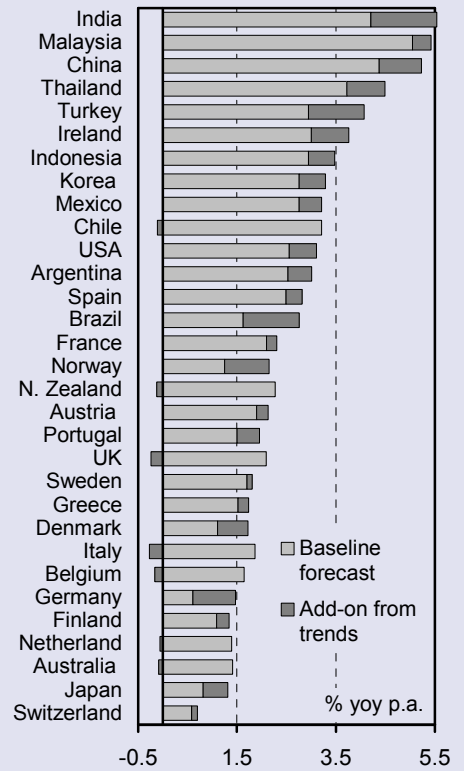
Source: Deutsche Bank Research

D. Implications for investors and politicians

The transparent analytical framework presented above allows us to now provide a detailed explanation of the expected growth rates of GDP, using our six growth stars as examples. This information gives investors a chance to augment or check their lists of test criteria. Politicians can adjust the rankings within their priority lists as required.

9. The secrets of success of the growth stars

Why are India, Malaysia and China the growth centres of 2006-2020 according to *Formel-G*? How can the strength of Ireland, the USA and Spain be explained? In these countries the strong development of fundamental growth drivers in the past coincides with a positive assessment of the trend speeds. Our growth model allows us to present the reasons of future growth transparently.[35]

India – a giant opening up internally and externally

First, India is helped by its strong population growth, which in our forecast at 1.6% per annum (2006-2020) is only just below the rate for the last decades. This accounts for a considerable share of the average GDP growth of 5.5% in our model-based forecast for the period 2006 to 2020 (compared with 5.7% between 1986 and 2000). In addition, we expect a growth-promoting acceleration in the six trend clusters in India: the trend analysis boosts GDP growth from 4.3% in the baseline forecast by 1 ¼ percentage points to 5.5%. For example, the opening of work and society will progress much faster than in the past. Of the emerging markets we expect India to post the fastest acceleration in this trend cluster. The "Restriction of growth" trend cluster will be even less pronounced than in the past and the energy dependency of India is below average. Global networking will accelerate at a similar pace as in China. Moreover, the healthcare sector will expand strongly from an extremely low level and life expectancy will rise appreciably.

The investment ratio should rise by more than 6 percentage points to around 30% between 2005 and 2020 thanks to the improved institutional conditions, thereby reaching roughly the same levels as in Malaysia and Chile at present. The average number of years of education – our proxy measure of human capital – should rise by more than two years (or more than 40%) between 2005 and 2020. This is the highest percentage increase of all the countries reviewed. However, at 7.3 years India would just be reaching the current level of Indonesia and half of Korea's level in 2020. Openness will also continue to increase strongly according to *Formel-G*.

Malaysia – factor accumulation

Malaysia should register the fastest population growth in our country group until 2020 at 1.7% per annum, which will make a major contribution to overall GDP growth of 5 ½%. The investment ratio should exceed 30% in the coming years and thus be much higher than the emerging market average. Human capital and openness will increase at an average rate. The trend development will contribute nearly half a percentage point to growth. Growth will thus be driven in Malaysia extensively by labour accumulation.
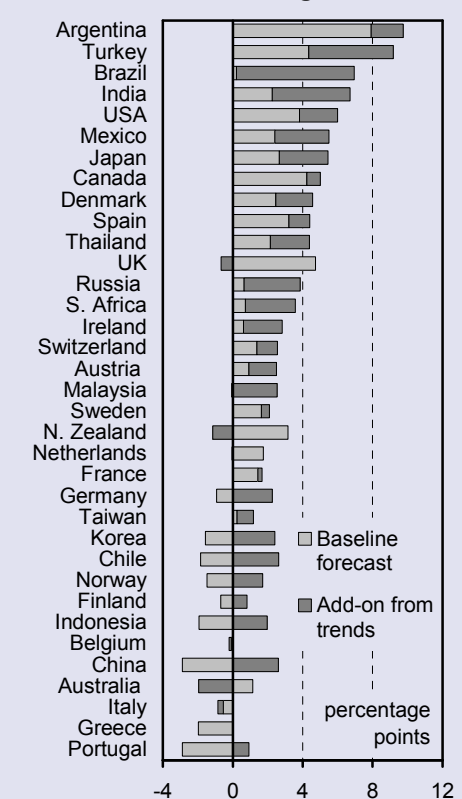
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[35] Unfortunately we cannot calculate growth contributions for the four drivers as this is not allowed by the combination of long-term and short-term coefficients with the convergence coefficient.

Population growth 2006-20

Sorted by total change

Baseline forecast (UN)

Add-on from trends

% yoy p.a.
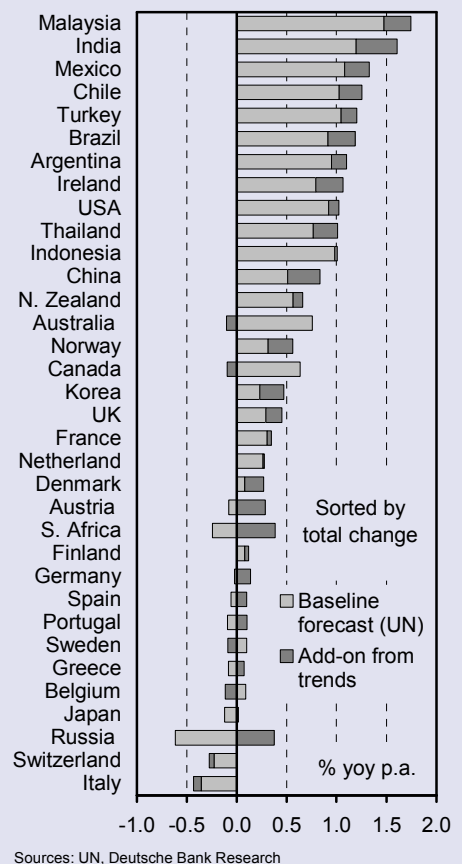
Sources: UN, Deutsche Bank Research

Investment ratio: change 2005-20

Baseline forecast

Add-on from trends

percentage points

Source: Deutsche Bank Research

China – internal catch-up process

Three years ago Deutsche Bank Research already identified China as one of the growth centres of the future and designated the country as a megatopic in its own right with a series of publications. Our new approach backs up this decision, even if it slightly dampens the current euphoria with growth for the period 2006-2020 forecast to start at nearly 7% and average 5.2%.

China's strong growth during the last 25 years stemmed largely from the pivotal transformation of the economic system from communism towards capitalism. Major growth determinants that are not explicitly factored into our model (above all domestic institutions, land reforms, freedom of settlement etc.) have improved appreciably. Strong growth was thus initially possible without a marked improvement in our four drivers. In the 1990s the rising investment ratio (up from 25% of GDP to 36% recently) and the opening up of trade in the last five years have made a major contribution to growth.

Our country experts forecast that openness will increase at a pace similar to that of the last five years thanks to far-reaching domestic reforms that will allow more exchange with foreigners. Moreover, the investment ratio will remain high at nearly 40%: the capital stock per capita will thus continue to grow strongly. The average number of years of education in our model will rise at a similar pace to that in India. However, population growth between 2006 and 2020 will average only 0.8% per year owing to the one-child policy – a little below the emerging market average of 0.9%. The bottom line is GDP growth averaging 5.2%. This success should not, however, be allowed to obscure the country's problems: pollution, banking sector, income inequality etc.

The emerging markets that perform relatively poorly according to *Formel-G* are **Argentina and Brazil**. Their improvement in human capital and openness is below average, while their investment ratio just matches the level of the OECD countries. In addition, our trend analysis only adds less than half a percentage point to GDP growth in these two countries. As a net energy exporter, Argentina will at least continue to benefit from rising energy prices.

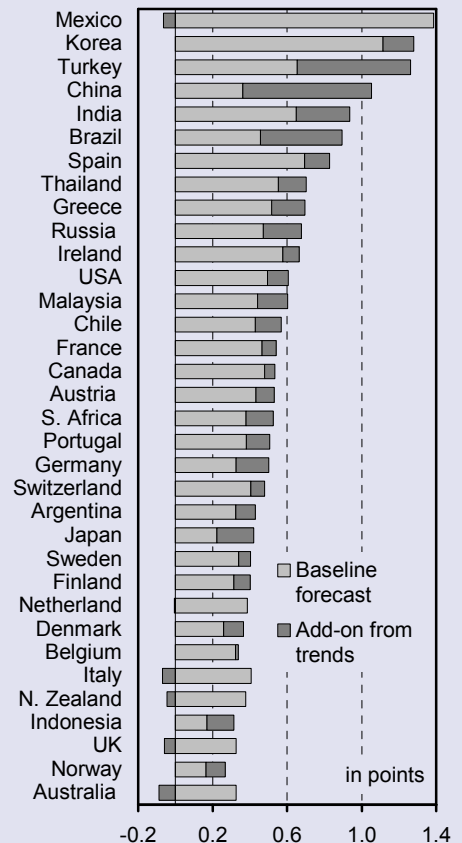## Ireland – the Celtic tiger still has some vigour

The Celtic tiger was the runaway star of the 1990s among the industrial countries, posting 7% GDP growth per year. Even though a considerable proportion of the income generated in Ireland is paid to foreigners, the income of the Irish has increased substantially. The opening of the economy has been decisive: from being one of the most closed economies in the mid-1970s, Ireland had become one of the most open in the world by 2002 according to our measure thanks to low tax rates and EU aid programmes – surpassed only by four countries from the centre of the EU. We expect the opening to continue at a similar pace in the coming years, although there is a great deal of uncertainty attached to this forecast. Human capital has also improved strongly and will continue to do so in our view. We expect the investment ratio to benefit from the acceleration of the "Enlarging scope of life" trend cluster where Ireland has lagged a long way behind in recent years. The new investment opportunities in the healthcare sector will establish a broader basis for growth in Ireland. Together with the highest expected population growth of the OECD countries of 1% this allows GDP growth overall of nearly 4% per annum – remaining the highest of any OECD country.

Human capital: change in years of education 2005-2020

Sorted by total change

☐ Baseline forecast
☐ Add-on from trends
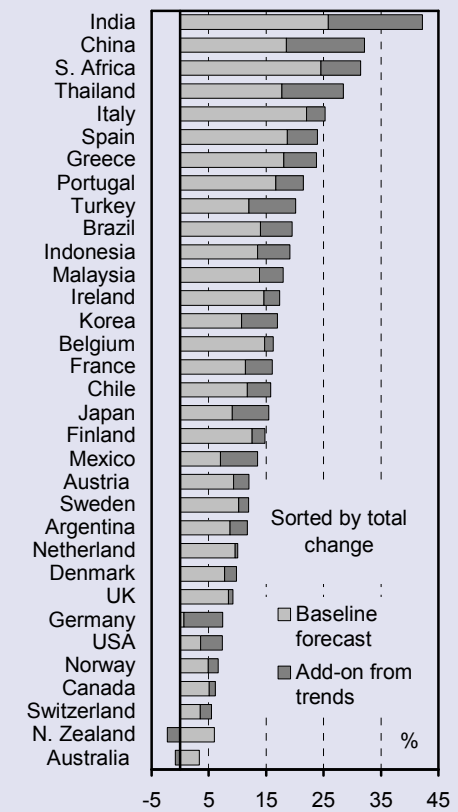
Source: Deutsche Bank Research

Openness: total change 2005-2020

☐ Baseline forecast
☐ Add-on from trends

in points

Source: Deutsche Bank Research

US – dominance to remain

The US will remain by far the biggest economy overall. On per capita GDP for our selection of countries it must at worst admit defeat to little Ireland. However, the expected population growth of 1% per year accounts for almost all the absolute growth gap compared with European countries like France and Italy. This is where some of the risks currently lie for the US, as the security precautions following September 11, 2001 are severely slowing the influx of foreigners and thus hindering one of the key factors in the country's success during the last 15 years.

Our trend analysis results in a growth add-on over the baseline forecast of half a percentage point. A particularly significant factor here is the dynamic innovative capacity of the USA. The trend clusters "Conquest of smallest structures" and "Process virtualisation" will continue to be driven particularly by the USA in the coming years. The currently still relatively low investment ratio should thus also continue to rise and draw closer to the OECD average. Average human capital will, by contrast, rise as slowly as in recent decades (chart).

Spain – the economy's strength is genuine

Spain has regularly ranked highly in the European growth league table in recent years. According to *Formel-G* these successes are sustainable and after flying high for some time there is no threat of a crash: Spain can maintain average per capita GDP growth of almost 3% over the next 15 years. The fundamental growth drivers human capital and openness have improved substantially in the last few years. According to our model-based forecast they will also continue to do so, even though uncertainty remains high on account of the structural breaks in the last decades. The number of years of education will rise between 2005 and 2020 at a rate similar to that in the last 15 years and increase by 2.6 years to 13.5 years – and thus reach the German level of the 1990s. The relatively high numbers of school pupils and students suggest that the new entrants into the workforce will possess a much higher level of human capital than the current average. Openness is also set to increase at a well-above average rate in the next 15 years and then reach France's level. Spain is ideally located as a bridge between Europe on the one hand and South America and North Africa on the other hand. Our trend analysis makes a small positive contribution to these findings.

If the immigration from North Africa and Latin America continues as in the last few years, then growth will be even higher than forecast by the model and Spain would be the growth star of the OECD countries. The *Formel-G* findings are based on United Nations projections that the population will shrink in the coming years. At the moment, however, it is growing at over 1 ½% per year thanks to high immigration.

The bottom end of the table

The countries at the bottom end of the growth league table include rich countries such as Switzerland, Japan and Italy with their shrinking populations. The trend analysis points to growth problems in Italy, the UK and Belgium. Germany occupies one of the bottom rungs of the ladder with forecast growth of 1.5% per year between 2006 and 2020. Population growth will be only minimal – and this will only come as a result of immigration. As indicated above, we expect a marked acceleration in some trend clusters (including the negative cluster "Restriction of growth"). All in all, this helps Germany in *Formel-G* to achieve a slightly above-average increase in openness and a stabilisation of the investment ratio at a low level (after declining for decades). The trend analysis boosts growth in German GDP by a total of nearly 0.9 percentage points per year.

Investment ratio with forecast

Source: Deutsche Bank Research

Years of education with forecast

Source: Deutsche Bank Research

Openness with forecast

Source: Deutsche Bank Research
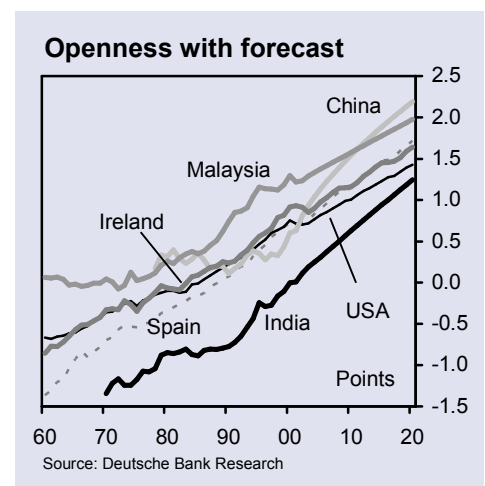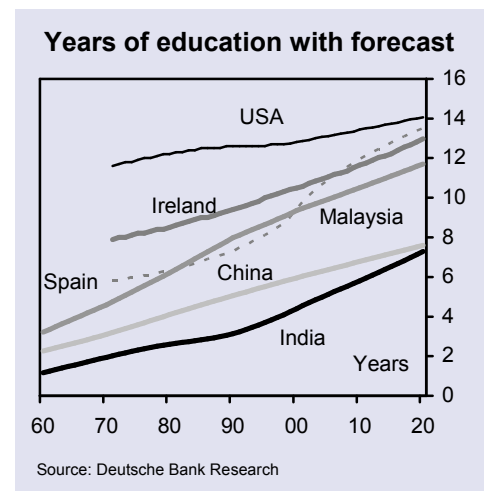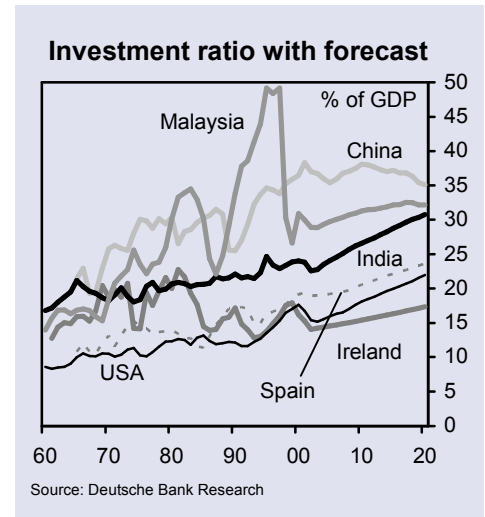
E. Limits of the model and outlook

The transparency of *Formel-G* has been clearly illustrated by the detailed descriptions of the expectations for our growth stars. The sound theoretical underpinnings, the new empirical methods, the extensive cross-country comparisons and above all the innovative trend analysis are the key strengths of our long-term model.

10. Limits of our growth model

Our model does however also have limits and shortcomings. First of all there are the usual **uncertainties of every forecasting model**: the slope coefficients in the econometric equation (i.e. the structure of the economies) could be different in the future than in the past; the restriction of the same long-run coefficients could be inappropriate for some countries; and the assumptions regarding the trend clusters might prove to be incorrect. In addition, many emerging markets have a volatile past with many exceptional situations behind them. This reduces the reliability of forecasts for South Africa and Turkey, for example. Dramatic events, such as a reunification of the two Koreas, uprisings against authoritarian governments or military conflict with neighbouring countries cannot be predicted by our model. They need to be handled with separate scenario analysis.

Necessary to make assumptions on coefficients and trend changes

In the long-term equilibrium analysed here, **interest rates, exchange rates, government deficits and current account balances** do not play a role – they take on a neutral level. If a country pursues a short-term expansionary business cycle policy that pushes GDP above its fundamental equilibrium, the model then forecasts a convergence back towards this equilibrium. However, it cannot forecast how long the variables above remain away from their neutral levels. However, in the long term, expansionary business cycle policy does not help. As mentioned above, a fundamentally unjustifiable gap to the fundamentals is reduced by half within three years.

Business cycle policy not taken into account

The model possibly also has problems with fully taking into account an increase in the **employment rate** caused by, for example, an increase in the retirement age. We factor in this possibility via the trend cluster "Opening of work and society" – which explains among other things the high trend markup for Germany.

Change in employment rates only partially discounted

The model does not include in the impact of **externalities** that lead to a trend of the concentration of economic activity. These externalities are responsible for some regional divergence for example within Germany and the US. Economic activity in Asia may be concentrated around Shanghai – which would mean that countries further afield would do worse than forecast by the model.

11. Outlook and series of publications

This introductory report has only been able to present the most important findings of the model, supply a first insight into the key fundamental drivers of long-term growth and briefly describe the trend clusters. The structure of our model and its strengths and weaknesses have been outlined.

In a **series of publications** over the coming months Deutsche Bank Research will present detailed assessments of the most important drivers and the trend clusters. Country reports will apply the analytical

framework to selected economies and analyse their specific strengths and weaknesses.[36]

Formel-G also produces clear policy recommendations: improved human capital, greater openness to other countries, economic freedom and rule of law are the keys to higher per capita incomes. To achieve this, the labour market and society must be opened up, the global networking of business and politics must become closer, an enlarging scope of life must be promoted and assisted and the restrictions on growth must be kept to a minimum. The richer countries can maintain their income advantages via process virtualisation and the conquest of smallest structures.

Clear policy recommendations can be derived

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[36] See, for example, "Turkey 2020: on course for convergence", Deutsche Bank Research, Current Issues, January 12, 2005. A study on India is due to be published soon.

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